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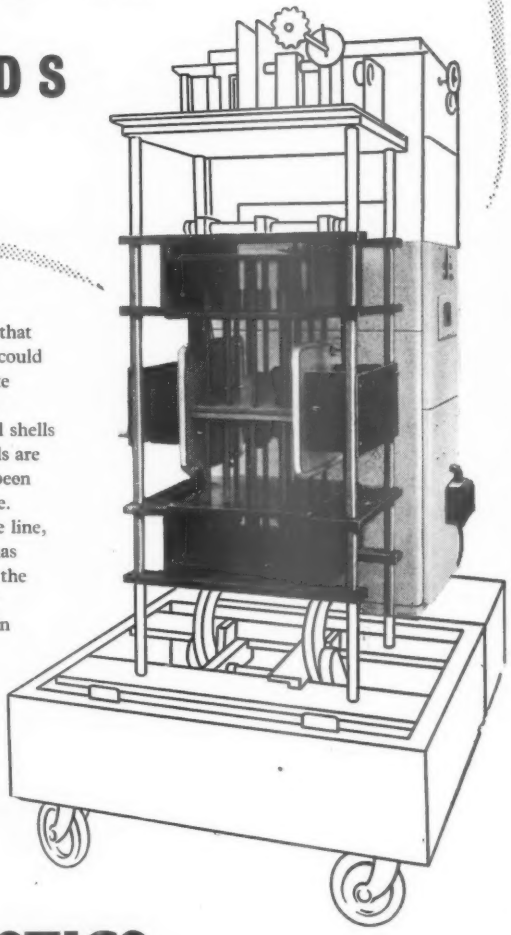

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Cost Consciousness

Perhaps, owing to a prolonged period of favourable trading conditions, much of the foundry industry has not been giving the attention to selling that the subject warrants. Only recently, our advice was sought by a prominent foundry owner as to whether he should use the same traveller for selling finished goods and castings. We counselled against such an economy, as to our mind two different mental attitudes are requisite. In the case of the finished goods, the representative can show samples, provide direct sales literature and quote prices, whereas the man who has to sell castings has none of these advantages. He has the task of convincing the buyer as to the services he can give to the buying firm by way of the many and various physical properties, such as hardness, machinability, pressure-tightness, and so forth, coupled with delivery conditions and price. Yet all that he may say may have but little in common with what the buyer has in mind, which may be acid- or corrosion-resistance or a number of other qualities.

Many foundries—especially those making non-ferrous castings—are well aware that they are losing money on certain lines, but recover these losses on other jobs made for the same customer. We often wonder whether these "fill-in" lines may not be another foundry's "bread and butter," and by not insisting on the correct selling prices a founder is inflicting a real harm on colleagues in the industry. Because of this, it does seem that local meetings of founders to discuss, not prices, but basic costs and their implication, might be a good insurance for when trade deteriorates. A quotation test carried out by the Association of Bronze and Brass Founders revealed a price ratio of one to two. This Association analysed these costs so that the firms submitting figures could find out where economies should be effected. A private case which came to our knowledge is worth citing. Here the prices, for a quantity production job, varied in the ratio of one to six, but maybe the high-price quotations were just one method of refusing the order. When such figures are examined it is often found that the major variables are "overheads" and weight calculations.

The castings salesman must be well aware of such variations and he has the unenviable task of convincing buyers that the services his firm can give will in the long run pay handsome dividends, stressing no doubt the hold-up which would result in the customer's production should high percentages of defects be encountered in the castings. Quality will always be the main weapon in the armoury of the castings salesman, and so long as this continues the foundry industry will never be subjected to enquiry by the Monopolies Commission.

Hadfields Bid for Millspaugh Opposed

Opposing the bid of Hadfields, Limited, steelmakers, of Sheffield, for Millspaugh, Limited, manufacturers of board and paper making machinery, etc., of Sheffield, three Millspaugh directors—Mr. Seymour Howard, Mr. K. F. Landegger, and Mr. M. F. Reid—claim that the figure of 7s. 6d. per stock unit of Millspaugh shown in the other directors' circular, when comparing capital values, is unduly low. The estimate of £450,000 for profits before tax for the year ended September 30, 1955, is most material, but no mention of it is made in the letter referred to. The offer was made by Hadfields before the 1954-55 figures were announced. Despite the results, the offer was not improved upon.

The dissentient directors take the view that the year's dividend should not be restricted to 12½ per cent., but that 20½ per cent. should be paid. The statement is challenged that Millspaugh will be better off under Hadfields control. Average profits for the three years ended September, 1954, are more than four times the average for three years ended September, 1950, they claim, adding that the company Hadfields is seeking to acquire is very different from that hived off in 1951.

Latest Foundry Statistics

According to the Council of Ironfoundry Associations, the following number of ironfoundry workers were employed in the United Kingdom during the week ending October 29: Males, 135,167, and females, 10,326, making a total of 145,493. On October 1, there were 144,727, whilst a year ago the figure was 140,952.

As reported by the British Bureau of Non-Ferrous Metal Statistics, the output of copper-base castings during October was 6,939 tons. A revised figure gives the output for the first ten months of this year as 58,543 tons. This figure can be compared with 50,858 tons for the corresponding period of 1954.

From figures of the British Iron and Steel Federation, employment in steel foundries on October 8 was 20,248, showing an increase of 333 since September 10. The weekly average production of steel castings during September was 6,700 tons. In August this average was 5,300 and in September, 1954, 5,900 tons.

Another Warning on Coal Stocks

A further warning on coal stocks was given at Bristol on December 8 by Mr. L. W. Joynson-Hicks, Parliamentary Secretary to the Ministry of Fuel and Power. "Owing to the weather, stocks of coal had continued to increase this autumn in a very satisfactory way, but the impression must not get around that people need not worry about coal," he said.

He told a Press conference that industry was supplied with its coal from production and stocks were intended to cover the increased consumption during the winter months, when the rate of production was always at about the same level. Stocks, he said, could simply melt away in winter and then we had to rely on production to keep us going.

Before meeting the Press, Mr. Joynson-Hicks addressed a private meeting of industrialists in connection with the Government's fuel-efficiency campaign.

Notes from the Branches

East Anglian Section

The highest attendance for many years was present at the second meeting of the session of the East Anglian section of the Institute of British Foundrymen when Mr. J. L. Francis discussed "Castings Defects." The Institute's "Atlas of Defects" and slides relating to this were used as the basis for reference. The section president, Mr. W. E. Cates, said that Mr. Francis needed very little introduction to those present—he was a founder member of the section and its secretary for the first seven years.

During his opening remarks Mr. Francis asked if there was anyone present who had not encountered a defective casting! Defective castings, he said, could be classified as follow:—(1) Those containing major defects which made the casting a total loss; (2) those in which the defect cost so much to repair that it was questionable whether to salvage or scrap the casting, and (3) those with minor defects which permitted economical salvage. Although all defective castings could not be classified as scrap, a defective casting always represented some loss to the foundry producing it. Even though slightly defective castings could be salvaged, there was an expenditure of time and material which affected the profitable operation of a foundry.

Many defects were caused by more than one operating factor acting either on its own or in combination with others. Also, many of the operating factors influenced the production of more than one type of defect. Thus, in order to prevent defects, the real cause or causes must be discovered and remedied. Many foundries still did not exercise sufficient control over the factors which could vary and contribute towards the production of defective castings.

The discussion was introduced as each slide was presented and this proved a very popular measure. Mr. Berry proposed a vote of thanks and spoke very highly of Mr. Francis' reputation in East Anglia and added that a very interesting evening had passed all too quickly.

South Africa

The monthly meeting held in Johannesburg on November 24, was addressed by Mr. H. Korver. Mr. de Kiewet, the president, introduced Mr. Korver as the originator in South Africa of the clay/plaster pattern process and stated that Mr. Korver would demonstrate the principles of strickle work as applied in the foundry and patternshop.

During the course of the evening, Mr. Korver demonstrated the strickling in clay of a bell mould and core which he subsequently cast in plaster. He also demonstrated the strickling technique used to produce a mould for a ship's propeller 20-in. dia. Another interesting part of the demonstration was the manufacture of a die for a spoon of the type used by line fishermen. Mr. Korver also discussed separating media for plaster, mixing and the production of patternplates and patterns by the clay/plaster process.

Mr. Godwin concluded the evening by proposing a vote of thanks to Mr. Korver for his most interesting demonstration. He also complimented Mr. de Kiewet, who acted as interpreter, the entire lecture and demonstration having been given in Dutch.

NORRIS WARMING (HOLDINGS), LIMITED, heating and ventilating engineers, of London, W.C.1—A London marketing is being arranged of the company's 1s. ordinary shares. The issued capital is £300,000 in 1s. one-class shares.

Gases in Cast Iron

Account of the British Contribution to the Study of this Problem submitted on behalf of the Joint Committee of the Institute of British Foundrymen and the British Cast Iron Research Association . . . . By the chairman, H. Morrogh*

The various anomalies alleged to be due to variations in the gaseous-element content of cast irons have been reviewed, and the difficulties in the determination of the gaseous-element content have been discussed. Many of the claims made for the influence of the gaseous elements in cast irons are not supported by actual evidence of variation in gaseous-element content. A Joint Committee of the Institute of British Foundrymen and the British Cast Iron Research Association has made an exhaustive examination of the techniques for the determination of the gaseous elements in cast iron and for the sampling of cast irons for these determinations. The need for this type of co-operative work is emphasized. Many of the results reported in the literature are of doubtful value because the methods used have not been subjected to this type of critical co-operative investigation.

The vacuum-fusion method has been chosen for the determination of oxygen and nitrogen, but a chemical method has also been used for the determination of the latter. The vacuum-fusion method is not ideally suited to the determination of hydrogen and an improved vacuum-heating technique has been developed. The sampling of cast iron for gaseous-element determinations is shown to be very important. Differing results for oxygen content may be obtained according to the position of the sample in sand-cast samples. Small chill-cast samples are shown to give reproducible results for oxygen, nitrogen and hydrogen using the vacuum-fusion process. Using small chill-cast samples, metal has been sampled at a number of works using a wide variety of melting units and melting practice. These results are presented in detail.

The influence of oxygen on chilling tendency and on the annealability of malleable iron has been studied. It has been shown that oxygen itself does not influence the chilling tendency or the annealability. The oxygen may appear in some circumstances to have a chilling tendency due to its combining with aluminium which has a graphitizing influence. The influence of nitrogen in cast iron has been studied in detail; it is shown to be a carbide-stabilizing element, the effect of which can be neutralized by small additions of aluminium. The influence of the amount of steel scrap on the gaseous-element content of cupola melted metal has been studied.

A satisfactory and very sensitive technique for the determination of hydrogen in cast-iron samples has been evolved, but much further work is required on sampling techniques for hydrogen estimations. The influence of carbon content on the solubility of hydrogen in iron/carbon alloys at temperatures up to 1,000 *deg. C. has been studied.*

Introduction

In September, 1946, a committee† jointly representing the Institute of British Foundrymen and the British Cast Iron Research Association held its first meeting. The terms of reference of the committee were:—

> *"To explore the gas content of cast iron in relation to pig-iron and the remelting procedure."*

Since the first meeting considerable work has been carried out. That originating from the British Cast Iron Research Association has been published as detailed individual papers[1 2 3 4 5 6 7 8 9] but it was thought opportune at this stage to issue a report on behalf of the Joint Committee so that foundrymen might learn more of the problems associated with work of this nature, of the progress made, and of the effort required in the future.

This Report is not intended to reproduce all the work of the Joint Committee but only that which it is thought has some bearing on the problem. For many years the attention of the Committee was devoted to methods of analysis, sampling, and the reproducibility of results, and it is only quite recently that it has been possible to consider the results obtained in terms of the problems of the industry.

As an introduction to the importance of this subject an account is given below of some of the problems and anomalies thought by many to be related to the gas content of cast irons. This is

* Presented at the International Foundry Congress in London, last June.

† The present membership of this Committee is given in Appendix I. Appendices and references will be printed with the concluding portion of the Paper.

followed by an account of the sampling and analytical techniques used for the determination of the gaseous elements in cast irons. Results obtained on irons produced at various typical industrial plants are next discussed. This is followed by a description of the work carried out to investigate the influence of deliberate variations of oxygen and nitrogen in cast iron. The special problem of hydrogen in cast iron is also considered. Finally, there is some discussion about the work remaining to be carried out in the future.

THE PROBLEMS

The gaseous elements oxygen, nitrogen and hydrogen are present in all pig-irons and cast irons, but in very small amounts. The amounts are indeed so small that those working in this field frequently speak of the gaseous-element content of cast iron in terms of parts per million. One part per million is equal to 0.0001 per cent. To obtain figures for the oxygen and nitrogen contents of cast iron which have any significance the methods used must be able to detect differences of ten parts per million (0.001 per cent.) and perhaps in some cases a sensitivity of five parts per million (0.0005 per cent.) and even lower might be required. For hydrogen it is necessary to estimate the content to at least one part per million (0.0001 per cent.) and future work may indicate a sensitivity of at least one part in ten million (0.00001 per cent.) to be required.

Hydrogen contents are frequently expressed as volume in millilitres extracted from 100 gm. of metal. 1 ml. of hydrogen per 100 gm. of metal is equal to 0.00009 per cent. by weight.

Those familiar with general metallurgical-analysis techniques will realize from these brief remarks that the estimation of the gaseous-element content of cast irons and pig-irons calls for care and experience far beyond that of the normal analytical laboratory. On many occasions during the last 50 years attempts have been made to determine the gaseous-element content of cast irons, but it is only perhaps in the last 15 years that figures of known accuracy and hence real significance have become available. In addition, many references to the effects of the gaseous elements in cast irons do not give figures for the gaseous-element content, and deductions about the influences of these elements are based on circumstantial evidence only.

Brief descriptions of the analytical techniques used will be given in a later section of this Report, but for details the reader will be referred to the several excellent specialized accounts which are already available in the literature. At this point it might be noted, however, that the apparatus and equipment for the determination of oxygen (and nitrogen) is likely to cost a minimum of £1,500. This expense largely arises from the fact that the apparatus usually uses high-frequency-induction heating; although Cook and Speight[13] have described an alternative form of heating which is likely to be cheaper, but this has not been tried for cast irons. Probably the provision of a laboratory for general work on this subject would represent a capital investment of £10,000. In addition, most of the analytical work involved calls for investigators skilled in high-vacuum techniques.

The influence of the gaseous elements in cast iron is a subject upon which many foundrymen have strong beliefs, based frequently on recurring experiences. The anomalous behaviour of certain cast irons has often been attributed to variations in gaseous-element content. It should be understood that present knowledge of the influence of the gaseous elements is as yet insufficiently developed to dismiss or confirm many of the foundrymen's beliefs, but it is thought that a position has been reached when some can be critically scrutinized. The brief account given in what follows summarizes some of the more important features requiring explanation. Their inclusion here does not necessarily indicate that the Committee accepts the popular view of the phenomena but they are included rather because they are regarded as problems requiring investigation and explanation.

Oxidized Metal and Oxygen in Cast Iron

Perhaps one of the most persistent beliefs concerns so-called "oxidized metal." Foundrymen are aware that when metal is melted under "oxidizing" conditions it appears to behave differently from metal melted under "normal" conditions even though the nominal analysis with respect to the commonly determined elements is the same in the two cases. The manifestations of oxidized metal vary with the section of the industry concerned.

In the malleable-iron industry, "oxidized metal" is a well-recognized condition and is produced by melting a large proportion of highly-oxidized scrap; by the development of a "bear" of iron in the bottom of a furnace which is not removed on tapping and which becomes progressively oxidized; by the use of wrong fuel/air ratios, giving slags of high iron-content with abnormal losses of carbon, silicon or manganese. It is claimed that the condition also arises when an oxygen torch is used to open a tap-hole. In the malleable-iron industry oxidized metal is commonly associated with poor annealability, with decreased fluidity, with increased unsoundness and with increased hot-tearing.

Tilley[12] has shown that the nodule number decreases (a condition usually resulting in slow graphitization rate) with increased loss of silicon during melting for the same final silicon content. This experience is fairly common and has given the widespread belief that melting under oxidizing conditions leads to an increased oxygen content even though there is no change in nominal analysis. Boegehold,[14] on the other hand, studied the effect of additions of Fe_2O_3 and Fe_3O_4 to malleable cast iron and from the temper-carbon distribution indicated that oxygen might have a carbide-stabilizing effect during annealing, although he noted an increased mottling tendency which might have indicated oxygen to have a graphitizing effect.

"Oxidized metal" is also recognized in the manufacture of grey-iron castings. The use of highly oxidized scrap, overblowing the cupola and inadequate ratios of fuel to air in other furnaces are conditions giving rise to this anomaly. "Oxidized metal" in the grey-iron industry gives blowholes, poor fluidity, porosity and inverse chill.

The powerful effect of melting under oxidizing conditions is well recognized by those concerned with the production of chilled-iron castings. Metal melted under oxidizing conditions tends to have a wide mottled zone, with a coarse mottle.

In all sections of the industry it is common to think of additions such as aluminium and ferro-silicon, made to the molten metal shortly before casting, as "deoxidizers." Thus, for instance, when additions of aluminium to white iron for malleabliz-ing tend to give an increased rate of graphitization it has been assumed by many that oxygen behaves as a carbide stabilizer and that the graphitizing effect of aluminium is obtained by the neutralization of the oxygen as alumina.

On the other hand, to confuse matters, it has been shown experimentally[10] and confirmed in practice that very small additions of the "deoxidizers" aluminium and ferro-silicon can have a carbide-stabilizing effect and it has, on this basis, been deduced that oxygen might be a graphitizer.

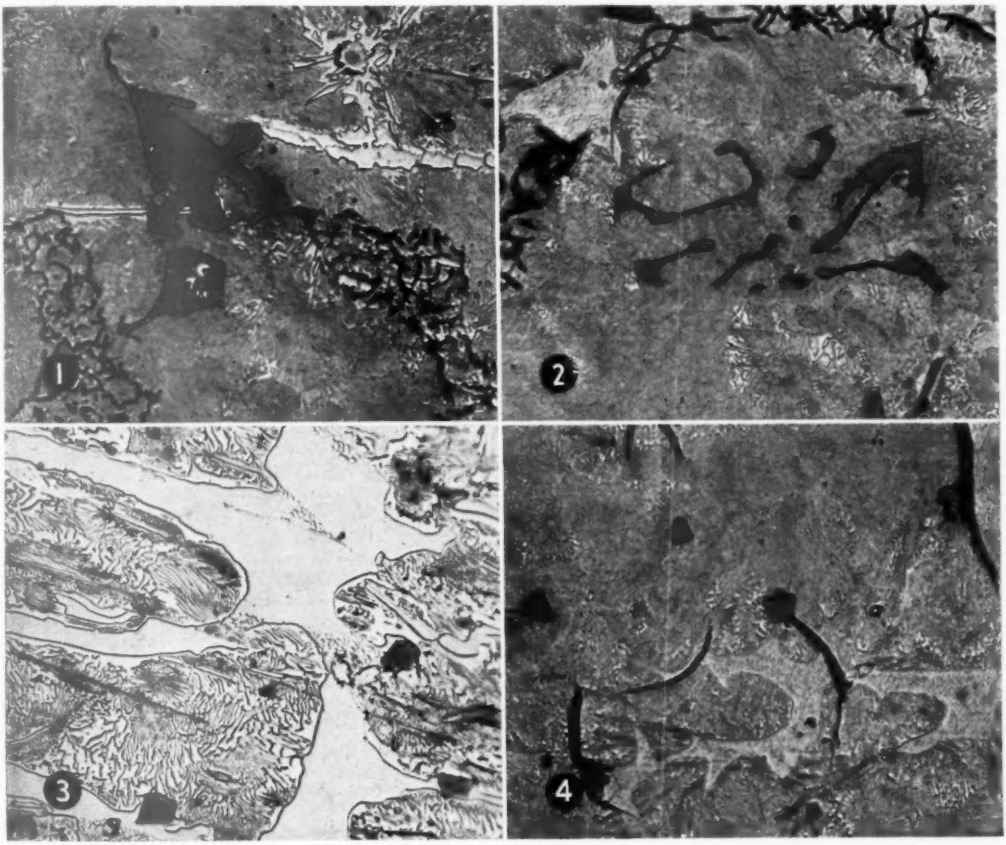
The chilled-roll industry is aware that the manganese-sulphide particles found in the microstructure can vary in shape and believes that large angular inclusions are associated with high thermal-shock-resistance of the roll. Williams[11] has studied these variations in manganese-sulphide

FIG. 1.—*Large manganese-sulphide particle in iron heated to* 1,350 *deg. C. Etched in picric acid;* ×600 (*after Williams*[11]).

FIG. 2.—*Elongated or anchor-shaped manganese-sulphide. Etched in picric acid;* ×600 (*after Williams*[11]).

FIG. 3.—*Compact manganese-sulphide particles in iron superheated to* 1,570 *deg. C. Etched in picric acid;* ×600 (*after Williams*[11]).

FIG. 4.—*Small, compact manganese-sulphide particles in iron treated with aluminium. Etched in picric acid;* ×600 (*after Williams*[11]).



shape and his findings may be briefly summarized as follow:—

(1) When normal cast irons, free from elements with a strong affinity for oxygen, such as aluminium, are melted at temperatures up to about 1,400 deg. C., and when these melts are not treated with "deoxidizing" additions such as aluminium or ferro-silicon before casting, the manganese-sulphide particles occur as large crystals which frequently have globules of entrapped metal and frequently assume anchor shapes, as shown in Fig. 1.

(2) By superheating to 1,500 deg. C., all the manganese-sulphide particles tend to assume elongated shapes, as shown in Fig. 2.

(3) By superheating to above 1,500 deg. C. the particles change to small compact crystals, as shown in Fig. 3.

(4) Treatment of the melt with ferro-silicon, calcium silicide or aluminium shortly before casting gives small compact crystals, as shown in Fig. 4, for all melting temperatures.

(5) By holding the melt after treatment with "deoxidizers" there is a gradual reversion to anchor-shaped particles.

(6) Treatment of a "deoxidized" melt with oxides gives a rapid reversion to elongated crystals of manganese sulphide (Fig. 2).

Since aluminium is regarded as a "deoxidizer" and since this gives small manganese-sulphide particles, there has been a tendency to assume that the small sulphide particles are associated with a low oxygen content and thus that superheating gives a low oxygen content. The Committee is not yet in a position to confirm these points, or the assumption that there is a correlation between the form of the manganese sulphide and the physical and mechanical properties of the iron. Very small additions of ferro-silicon can increase the chilling tendency of an iron and large additions have a graphitizing effect, yet small and large additions refine the manganese-sulphide particles. Late additions of graphite have a pronounced graphitizing effect and yet have no influence on the form of the manganese sulphide.

From this review so far it is obvious that "oxidized metal" is a very real thing but in the context of this Report the Committee is concerned to establish whether the effects observed are due to actual variations in oxygen content. In this connection it should be borne in mind that normal cast irons contain small amounts of many easily oxidized elements, such as titanium, aluminium, lead, antimony, tin, etc. Melting under oxidizing conditions could remove some of these elements without actually influencing the oxygen content of the iron in a decisive manner. The elimination of residual elements then would be responsible for the observed effects and not variation in oxygen content. As will be seen in a later section of this Report, this is a subject which has received some attention.

"Oxidized metal" is often described as having a "poor life" meaning that the metal solidifies more quickly than usual and therefore has a reduced fluidity, even though the composition is essentially normal. A little thought suggests that it is extremely unlikely that variations in the gaseous element content will cause molten metal to cool more rapidly or raise the freezing point. Evans[12] has studied the fluidity of cast iron and has shown that carbon, silicon and phosphorus have a pronounced influence on fluidity, but that pouring temperature is even more important. Evans examined several cases of "oxidized metal" and was able to show that the "poor life" was due to the fact that the metal was relatively cold and, furthermore, if the actual measured pouring temperature was taken into account in relation to the composition the iron was not abnormal in respect of its fluidity.

In various ways, abnormal oxygen contents are believed to occur in some molten metal, leading subsequently to blowholes and even increased porosity. The inclusion of a large proportion of highly-oxidized scrap has been noted to give iron prone to inverse chill, and it is common to talk of the carbide-stabilizing effect of oxygen in this connection. The careful work of Williams[4 11] provides circumstantial evidence that oxygen might be a graphitizer but this appears to have been ignored by most foundry metallurgists.

Perhaps one of the most important troubles with which the foundryman has to deal is the apparently anomalous occurrence of porosity or sinking in castings, which suddenly develop without apparent change of practice. This is often blamed on the varying oxygen-content of the metal or upon an abnormal oxygen-content in the pig-iron used.

Speculation about and a desire for knowledge upon the effect of oxygen in cast irons and pig-irons has not been the exclusive field of the practical foundryman. The theoretical metallurgist has developed numerous theories from time to time to explain various phenomena and many of these concern oxygen and the form of oxygen in cast iron. The foundry metallurgist has been greatly influenced by the literature dealing with oxide and silicate inclusions in steels. Undoubtedly oxide and silicate inclusions are present in easily recognizable form under the microscope in most steels. On the other hand, Morrogh[15] has shown that such particles occur very rarely in cast irons and pig-irons. This is in accord with the generally low oxygen-content of most cast irons, as will be shown later. Most oxides and silicates are reduced fairly rapidly by the carbon of a melt at temperatures above 1,400 deg. C. and molten cast iron at such temperatures quickly develops a clear surface. On cooling, an oxide-silicate film forms on the surface of the molten metal and with turbulent casting this could become mixed with the metal to generate inclusions. Although this would seem probable, the presence of inclusions from such a source has not been definitely established.

Oxygen is most likely to be evolved from molten cast iron as carbon monoxide but on theoretical grounds it would seem improbable that this gas

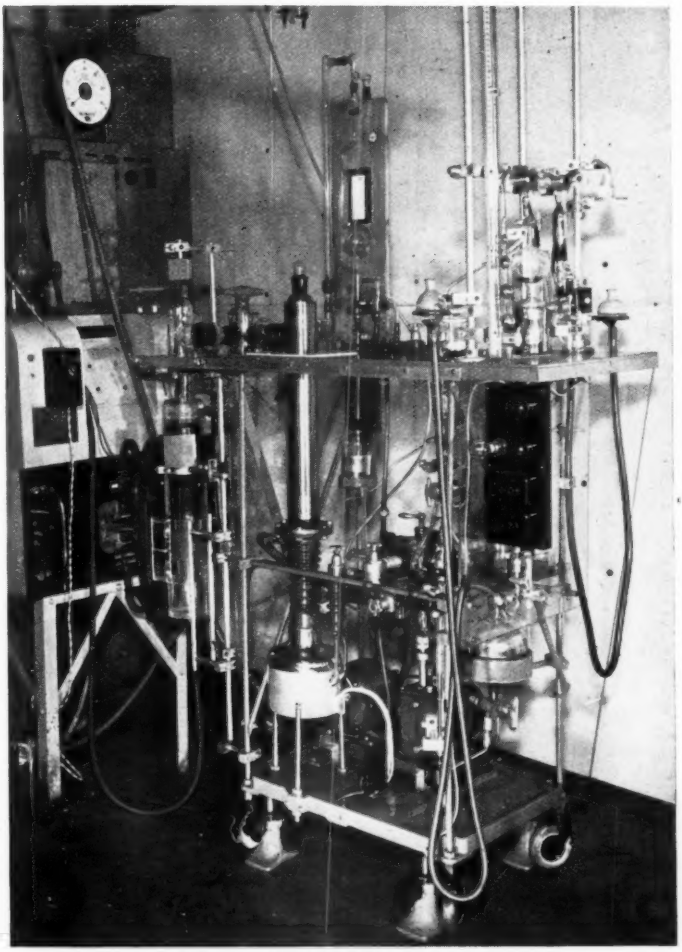


FIG. 5.—*General view of the vacuum-fusion apparatus at the British Cast Iron Research Association.*

is evolved at temperatures below 1,350 deg. C. The possibility of carbon monoxide evolution during solidification is of great importance for the production of castings, since it is during solidification that gas evolution determines the soundness of a casting. Excessive gas evolution during solidification may give rise to porosity, but for porosity arising from solidification shrinkage to occur it is probably necessary that some gas should be evolved. If no gas evolution occurs during solidification "sinking" or "drawing" is likely to occur.

Many foundrymen comment on the blue flames seen to form on the surface of some metal standing in the ladle. When this occurs in iron for chilled rolls it has been noted that such rolls are susceptible to pinholing and it is suspected that the flames are an indication of an unduly high gas-content. The colour of the flames suggests that carbon monoxide is being evolved. This could be produced by the reaction of carbon in the metal with slag, oxides and refractories, provided the temperature of the metal is not too low.

This brief summary indicates the manifold beliefs about oxygen in cast irons and pig-irons. It is nearly impossible within the compass of one short report to describe all the views of the practical foundryman on this subject. His opinions are usually difficult to investigate and based on circumstantial evidence; nevertheless they are frequently so firmly and justifiably held that the clarification of the rôle of oxygen in cast irons and pig-irons and oxidation during melting clearly deserves the highest priority.

Hydrogen

Hydrogen is generally considered to be an important element in cast irons and pig-irons. It might be introduced from the water-vapour of the atmosphere, from damp refractories, from the fuel and the products of combustion of the fuel, from melting stock and alloy additions. Hydrogen is commonly thought of in connection with unsoundness in iron castings. This is a very reasonable supposition, since it has been clearly shown in the literature that the solubility of hydrogen in pure liquid iron shows a sharp decrease on solidification. Hydrogen evolved during solidification would lead to blowholes and interdendritic porosity and what applies to pure iron in this connection is likely also to apply to cast irons in a somewhat modified manner.

There seems to be good circumstantial evidence that hydrogen is easily picked up by metal from damp refractories and ladle linings. Contact of molten metal with damp refractories is a well-recognized cause of blowholes in the subsequent castings. It is reported that badly "blown" sand-cast pig-iron (presumably arising from damp pig beds) has given rise to porous castings with as little as 10 per cent. of this pig-iron included in the charge. All conventional moulds, and certainly green-sand moulds are a source of water-vapour and hence potentially of hydrogen. It is conceiv-

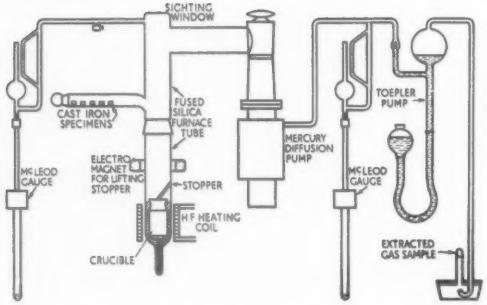


FIG. 6.—*Diagram showing essential details of the vacuum-fusion apparatus (after Hurst and Riley*[25]*).*

able that molten metal in contact with a green-sand mould undergoes considerable modification in hydrogen content. It is a practice to discard the first tap from a cupola which is often too cold for normal use. It is believed by some that such metal has a higher hydrogen content than normal due to contact with damp refractories.

The influence of hydrogen on the soundness of the 13 to 15 per cent. silicon acid-resisting cast irons is well recognized. Hydrogen appears to be readily soluble in liquid iron/silicon alloys but to have very limited solubility in the solid. Unless special precautions are taken to maintain the hydrogen content of high-silicon cast irons at a low value extreme unsoundness accompanied by "bleeding" on an extensive scale occurs. Riley[16] recommends that the hydrogen content of high-silicon iron should be maintained below 2 ml. per 100 gm. of metal in order to avoid porosity. The raw materials for the manufacture of these alloys must be chosen with great care. To some extent, an excessive hydrogen content may be reduced by repeated melting and solidification, some hydrogen being lost during each solidification. It is important to prevent the molten high-silicon iron making contact subsequently with damp ladle refractories in order to prevent a further pick-up of hydrogen.

It is reasonable to suppose that what applies to the high-silicon irons also applies in some measure to normal white and grey cast irons. A high hydrogen-content in the liquid metal might cause unsoundness which it is impossible to correct by feeding. High hydrogen-contents might originate from the melting stock and also from every source of moisture. It must not, however, be assumed that a very low gaseous-element content is necessarily a good thing for all castings. It is conceivable for instance, that with very low gas-contents there is inadequate gas evolution to permit the solidification contraction to give porosity and as a result sinking or drawing might occur which, in some cases, might be more undesirable than porosity. At the present stage it is impossible to state whether these considerations have any significance, but at least they have to be borne in mind until they can be proved or disproved.

Foundrymen producing castings for vitreous enamelling are also concerned about the possible effects of gases in cast irons on the enamelling operation and hydrogen has often been spoken of as a possible cause of blister formation. This defect is now fairly generally assumed to arise from surface oxides produced during processing and to surface-adsorbed gases, and not to gases inherent in the metal itself.

Frequently, certain samples of ferro-silicon used as inoculants give rise to blowholes. There is still much conjecture on this point but the defect is often thought to be due to an abnormally high hydrogen content in the ferro-silicon. There is some evidence to indicate that heating the offending alloy to dull red heat will cure this trouble. Sometimes this defect appears to be associated with a high aluminium-content in the ferro-silicon but a precise correlation has not yet been obtained. In this connection it is interesting that the addition of aluminium metal along

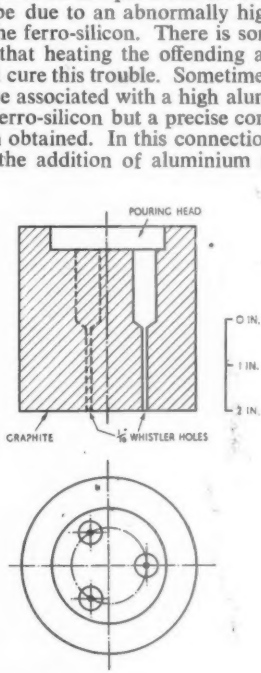


FIG. 7.—*Graphite sample-mould for gas analysis (after Bach, Dawson and Smith*[6]*).*

with ferro-silicon appears to cause blowholes. Certainly ferro-silicons can have much higher hydrogen contents than molten cast irons and figures ranging from 0.0002 to 0.0038 per cent. (2 to 38 p.p.m.) have been given for the hydrogen contents of various ferro-silicons.[31]

The metallurgical influences of hydrogen also have to be reckoned with. Hydrogen is commonly believed to be a carbide stabilizer and certainly it is well proved that hydrogen present in a malleable-iron annealing atmosphere has a powerful carbide-stabilizing effect. Hydrogen picked up from atmospheric moisture is frequently regarded as responsible for erratic chilling of small castings and the use of cupola air-blast drying has been advocated[17] to overcome this difficulty and to give more uniform results. Boyles[18] has shown that melting in

an atmosphere of hydrogen promotes a carbide stabilizing effect, and Norbury and Morgan[19] and Boyles have shown that treatment of a melt with hydrogen tends to give coarse-flake graphite.

Recently it has been shown that hydrogen present in the annealing atmosphere helps sulphur to give graphite spherulites[20] in malleable iron.

A subject of great interest in this connection is the reported different behaviour of metal according to the melting unit used. This might be due to variations in gaseous-element content. Related to this are the effects of melting and casting temperature on chilling tendency and graphite structure. Hotter melting tends to increase the chilling tendency. Can this be due to a change in the gaseous-element content or is it a nucleation effect?

Hot-tearing is an ever present trouble in the malleable-iron industry and also in the chilled-roll industry. This particular defect is always present to some extent but periods occur when the defect increases suddenly. So far it has not been possible, in the malleable-iron industry, to relate these outbreaks of hot-tearing to variations in mould or core conditions, to melting temperature, to pouring temperature or to metal composition. It is natural that the possibility of the gaseous elements influencing this condition should be considered.

It is clear from this brief account that there are many views about the influence of oxygen and hydrogen in cast iron and that they have been associated with almost every casting defect besetting the ironfounding industry. The work described in this Report has been carried out in full cognizance of these beliefs and it is recognized that the research worker, in spite of the large amount of work already carried out, is only now in a position to investigate some of these problems. It must be remembered that some of the effects attributed to gases in cast iron are not well authenticated and certainly only on most rare occasions, and this only recently, has there been any attempt to provide actual gas analyses.

The anomalous behaviour of cast irons might be attributed to unpredictable variations in gaseous-element content, but equally they might be due to unknown variations in trace-element content. Furthermore, the occurrence of defects such as porosity, sinking, drawing, hot-tearing and cracking might be considerably influenced by mould variations.

Nitrogen

Finally, it might be observed that the practical foundryman does not appear to have been particularly concerned about nitrogen in cast iron. Cowan[21] has suggested that nitrogen acts as a carbide stabilizer, but produced no evidence to justify this. Rauterkus[22] claims that the addition of aluminium followed by bubbling nitrogen through the melt gives an inoculating effect, and Jordan[23] has stated that nitrogen added to nodular irons increased their toughness. Collaud[32] gave the nitrogen contents of 34 cupola-melted irons of a wide range of compositions. He showed that the nitrogen content tended to decrease with increasing carbon-equivalent value. He reported values ranging from 0.0012 to 0.0068 per cent. (12 to 68 p.p.m.) nitrogen in his irons. Collaud also suggested that nitrogen was a carbide stabilizer without producing any evidence to support his statement. In general, however, it appears to have been tacitly assumed until recently that nitrogen behaves in an inert manner in cast irons.

ANALYSIS AND SAMPLING OF CAST IRONS AND PIG-IRONS FOR THE ESTIMATION OF THEIR GASEOUS ELEMENTS

The terms of reference of the Joint Committee drew attention to the need for information on the gas content of cast irons and pig-irons. The first task of the Committee was to decide on suitable techniques for the determination of the gaseous-element content of its materials. A considerable amount of work on this subject had already been carried out in connection with steels and several members of the Committee had long experience of this work. It was quickly decided that the so-called " vacuum-fusion method " was most likely to be best for the simultaneous estimation of oxygen and nitrogen. The vacuum-fusion method would also give a figure for hydrogen, but it was early realized that a detailed study of this element might involve the use of the " vacuum-heating " method. Attention was first concentrated on the vacuum-fusion technique.

The vacuum-fusion method for the determination of gases in steels was largely developed in this country through the efforts of Sloman[24] at the National Physical Laboratory. The experienced advice of this investigator on the Joint Gases Committee was of great help in the establishment of the technique for cast irons. The apparatus used for the vacuum-fusion method has been described in detail by Sloman,[24] Hurst and Riley,[25] and by Bach, Dawson and Smith.[26] This technique is very much for the specialist and it is extremely unlikely to be suitable for routine use in a foundry laboratory. For details the reader is referred to the original accounts. In principle, the method and the apparatus involve the melting of a small sample of iron (about 20 gm. in weight, usually machined) in a graphite crucible in a water-cooled silica furnace-tube in which a high vacuum is maintained by an appropriate train of vacuum pumps. The melted sample is raised to a temperature of about 1,600 deg. C. and nitrogen and hydrogen are evolved in elemental form, and oxygen as carbon monoxide. The mixture of evolved gases is stored and then analysed by more-or-less conventional techniques, and the oxygen, nitrogen and hydrogen content of the original sample calculated. The graphite crucible and its contents are heated, usually by high-frequency induction, but other forms of heating have been described.[33] The actual layout and appearance of the apparatus vary somewhat from laboratory to laboratory, but they all operate in the same basic manner. Fig. 5 shows the apparatus in use at the British Cast Iron Research Association, and Fig. 6 the essential details of a vacuum-fusion apparatus in diagrammatic form. In actual fact the whole apparatus is more complex than Fig. 6 indicates, as will be seen by those who study the original references. The equipment is usually designed so that up to about six specimens are stored in a side arm and are transferred to the

crucible by means of a magnet. After these samples have been analysed, the furnace chamber and crucible assembly have to be dismantled, the crucible assembly has to be replaced, and the side arm has to be charged with a fresh set of samples. On this account, even when the apparatus is functioning perfectly, it is only feasible to analyse six to eight samples each day, but normally the speed of analysis is not so high as this.

Great care and cleanliness is necessary in operating a vacuum-fusion apparatus. Before the crucible can be charged with its first sample it is heated gradually to about 2,500 deg. C. and maintained at this temperature for about 3 hours. During this time the vacuum in the furnace is maintained at a pressure not greater than about 10^{-4} mm. of mercury and usually much lower. This procedure is to remove adsorbed gases from the crucible and the graphite powder packed around it. After this, the temperature is reduced to about 1,600 deg. C., which is the operating temperature. The blank evolution of gas is determined over a period of about an hour. This blank value is regarded as satisfactory with the apparatus at the British Cast Iron Research Association when it is about 0.02 ml. of total gas per hour. Before beginning a run, the internal surfaces of the apparatus and the surface of the specimen must be absolutely clean.

In the early stages, the Joint Committee carried out many tests to confirm that the results obtained in one laboratory were reproducible in another. At first, considerable differences were found between various laboratories arising from variations in vacuum-fusion and gas-analysis procedures. The difficulties experienced were such that the Committee accepts with reserve results reported elsewhere and obtained without this type of co-operative checking and cross-checking.

When this stage had been accomplished it was decided to apply the vacuum-fusion technique to the analysis of some normal cast irons to see how the gas content varied from casting to casting from a given tap and in different parts of the same casting. To enable this to be carried out a number of test castings were specially prepared for the Committee* by metal melted and cast according to practice normal in the foundry concerned. These test castings were made from cupola-melted metal in green-sand moulds. The details of the charges and method of casting are as follow:—

Charge in Cupola(normal)	lb.
Hematite (2.5 to 3 per cent. Si)	70
Derbyshire Pig-iron	130
Bought scrap	50
Remelted scrap	300
	550
Coke	75
Limestone	18

An extra 10 lb. of coke was added to boost the temperature.

* These test castings and all the relevant data were kindly supplied by Mr. P. A. Russell of S. Russell & Sons Limited, Leicester.

The composition sought was:—Total carbon 3.35; silicon 2; and phosphorus 0.70 per cent.

Two different irons were usually made from this cupola—2 per cent. Si and 1.5 per cent. Si. A splitting charge of 75 lb. of coke was put through immediately before the samples were tapped to ensure a constant composition as far as possible. The melting rate of the cupola was 3.8 tons per hour with an air flow of 2,000 cub. ft. per min.

Three 5-cwt. ladles of metal were tapped from the cupola, the tapping temperature being 1,380 deg. C. These were then poured into a 15-cwt. ladle to give a 15-cwt. bath of metal of the same composition. A covering of coke-dust was applied to help maintain the temperature. It was not possible to pour moulds directly from the 15-cwt. ladle, so metal was transferred to a 5-cwt. shank and from this into the moulds. Nine boxes were poured from each 5-cwt. shank. The pouring temperature of the first set of boxes was *c.* 1,300 to 1,250 deg. C., the next set 1,280 to 1,250 deg. C., and the final set 1,250 to 1,220 deg. C. The three lots of castings were kept separate and stamped. The castings were in the form of 12 by 6 by 1 in. slabs cast two in a box. The slabs were cast flat, the $\frac{1}{2}$-in. gate running the full 12 in. length of the slab, and were fed from a 12 by 1 by 1 in. feeder, running the full length of the gate.

Moulding Sand:—Synthetic sand was used containing: 8 per cent. Fulbond; 8 to 10 per cent. coal-dust; and 5 per cent. moisture.

Actual analytical results obtained on the slabs were:—

TABLE I.—*Gas Analyses on Slabs.*

Sample Ref. No.	Date Analysed.	Laboratory.	Oxygen p.p.m.	Nitrogen p.p.m.	Hydrogen p.p.m.
1.A	29.3.49	No. 1	14	37	1.1
1.A	15.9.49	No. 1	29	33	1.1
1.B	23.5.49	No. 2	31	36	1.9
1.B	26.4.49	No. 2	38	31	1.8
1.B	25.8.49	No. 2	29	35	1.9
1.AG	5.4.49	No. 1	38	38	1.3
1.BG	31.5.49	No. 2	30	33	2.0
1.BG	26.4.49	No. 2	32	42	1.9
1.BG	25.8.49	No. 2	29	33	1.9
2.A	29.3.49	No. 1	14	32	0.9
2.A	15.9.49	No. 1	28	26	1.5
2.B	23.5.49	No. 2	32	45	2.0
2.B	26.4.49	No. 2	38	35	1.5
2.B	25.8.49	No. 2	30	32	2.1
2.AG	5.4.49	No. 1	30	32	1.1
2.BG	31.5.49	No. 2	36	35	2.2
2.BG	11.5.49	No. 2	29	40	1.9
2.BG	25.8.49	No. 2	25	35	1.8
3.A	29.3.49	No. 1	11	23	0.9
3.A	15.9.49	No. 1	22	24	1.1
3.B	23.5.49	No. 2	22	42	2.2
3.B	11.5.49	No. 2	33	30	1.9
3.B	25.8.49	No. 2	33	40	2.1
3.AG	5.4.49	No. 1	25	26	1.2
3.BG	31.5.49	No. 2	42	44	2.1
3.BG	11.5.49	No. 2	37	40	2.0
3.BG	25.8.49	No. 2	30	35	2.2

Notes.—(1) The first figure in the reference No. indicates from which part of the pour the slab came, i.e., No. 1 was poured first, etc.
(2) A and B signify two *different* slabs from the *same* part of the pour.
(3) G signifies the gate end of the slab, the gate running the whole 12 in. length of the slab, while the slices were taken at right angles to the gate, giving an approximately 6 by 1 by 1-in. bar.

	Slab 1A.	Slab 2A	Slab 3A
T.C.	3.47	3.43	3.39
Si	1.94		
Mn	0.64		
S	0.156		
P	0.50		
Ni	0.20		
Cr	0.05		
Mo	0.02		
Cu	0.06		
Ti	0.05		
V	0.07		

The gas analyses obtained by two co-operating laboratories are given in Table I.

It can be seen from these early results that there was encouraging agreement between the two laboratories but Laboratory 2 tended to obtain somewhat high oxygen and hydrogen figures and slightly higher nitrogen figures than Laboratory No. 1. Nevertheless, the results did appear to indicate that slabs poured at different times from the same metal and cast into different moulds gave similar results.

(1) Part of the gas is present in the voids as free H_2, N_2 and CO (or CO_2).

(2) Part of the gas is present as water-vapour.

(3) The oxygen is present in the voids as solid oxide. This could have been present in the metal when cast or could subsequently have been formed by rusting in the pores.

If explanation (1) be assumed correct, Table II shows the pressures that would be required to compress the gas into the voids. In view of the high pressures necessary, this explanation is not considered likely.

Even assuming that all the hydrogen was present as water-vapour, there is still a considerable amount of oxygen to be accounted for.

Explanation 3 is considered to be the most likely, but whether the oxide was formed by oxidation at high temperatures during cooling or by subsequent

TABLE II.—*Gas Content of Samples Taken Across the Width of Slab* 2A.

Sample No.	Density.	Vol. of voids, v. ml. per 100 gm.	Oxygen, p.p.m.	CO, ml. per 100 gm.	Nitrogen, p.p.m.	N_2, ml. per 100 gm.	Hydrogen, p.p.m.	H_2, ml. per 100 gm.	Total gas, ml. per 100 gm.	Pressure (atmospheres) (calculated).
T1	7.08	0.04	20	2.8	51	4.1	2.0	2.2	9.1	
T2	7.05	0.10	24	3.4	56	4.5	1.8	2.0	9.9	
T3	7.09	0.02	69	9.7	60	4.8	1.9	2.1	16.6	
T5	6.84	0.53	120	16.8	51	4.1	2.1	2.3	23.2	31
B5	6.87	0.47	560	78.4	34	2.7	15.0	16.7	97.8	194
T6	7.02	0.16	72	10.1	49	3.9	2.5	2.8	16.8	63
T7	7.07	0.06	69	9.7	56	4.5	1.9	2.1	16.3	163
T9	7.09	0.02	26	3.6	44	3.5	2.0	2.2	9.3	
T10	7.09	0.02	24	3.4	48	3.8	1.7	1.9	9.1	
B10	7.10	0.00	23	3.2	25	2.0	1·4	1.5	6.7	

The prefix T indicates that the sample was taken from the upper half of the slab and the prefix B indicates a sample from the lower half.

Samples were then taken across the entire width of slab No. 2A at the mid point of the length. The results obtained are given in Table II. The weight percentage of each gaseous element is given and also the volume of gas in each 100 gm. of metal calculated from the weight percentage is included. It has been assumed that oxygen if evolved would appear as carbon monoxide and so in the case of oxygen the equivalent volume of carbon monoxide is indicated.

These results showed a very wide variation according to the position within the slab, particularly at positions T3, T5, T6 and T7 corresponding roughly to the mid-width positions. These samples had extremely high oxygen figures and sample B5 had a very high hydrogen content. The density of these samples was determined before analysis and the values obtained are also recorded in the Table. It will be noticed that the high oxygen contents coincide with low density values, suggesting the presence of porosity. This slab was radiographed before analysis and considerable porosity was evident in the region of samples 5, 6 and 7.

The gas contents of the porous samples, especially B5, are very high compared with the usual values for normal cast irons. In view of the fact that the high gas content is associated with porosity, any explanation of the cause of the high values must take the porosity into account.

Possible explanations of these phenomena include:—

rusting would require further investigation. The ratio of oxygen to hydrogen would point to the formation of rust as being very likely (an average composition of rust being $Fe_3O_4.H_2O$). In any case it is clear that great caution must be exercised in interpreting the results obtained on samples which are not perfectly sound.

Prior to these results, Hurst and Riley[25] had made the first exhaustive examination of the gaseous-element content of various British pig-irons, using careful but otherwise normal sampling procedures involving trepanning suitable samples from various British pig-irons. They reported substantial variations in hydrogen content, variations in oxygen content from 0.001 to 0.080 per cent. (10 to 800 p.p.m.) and in general a high oxygen result was accompanied by a high hydrogen result. The nitrogen contents were confined to fairly narrow limits, ranging from 0.001 to 0.006 per cent. (10 to 60 p.p.m.). These investigators were disinclined to draw any conclusions from the results presented and in the light of the results on the slabs it should be remembered that they were unable to ensure the soundness of all their samples, some of which were from pigs probably held in stock for a considerable period, during which time some oxidation or rusting could have occurred.

Subsequently, work at the British Cast Iron Research Association[6] indicated that variable results were obtained on sand-cast grey-iron samples taken from various positions along the length of

TABLE III.—*Variation of Oxygen, Hydrogen, and Nitrogen along Keel Block Samples (Bars cut into seven pieces, Nos. 1 and 7 being at the ends and No. 4 at the centre.) Gaseous elements in p.p.m.*

Ref. No.		Sample No.							Composition, per cent.				
		1	2	3		5	6	7	T.C	Si	P	Mn	S
G.2A	O	15	17	38	36				3.2	1.9	0.05	0.5	0.14
	H	1.2	0.8	1.3	0.8	—	—	—					
	N	48	47	63	54								
G.28	O	19	34	36		35	34		3.8	1.8	0.06	0.7	0.03
	H	1.0	1.4	1.5		1.3	1.5						
	N	38	53	38		37	37						
G.45	O	54	66	61		79		65	3.6	2.8	0.06	0.8	0.02
	H	2.0	3.2	6.0		3.4		2.5					
	N	23	42	44		22		27					
G.52	O	11			18	15		12	3.5	1.4	0.07	0.5	0.08
	H	0.7			0.6	0.7		0.6					
	N	45			49	47		43					

keel blocks, as shown in Table III.

Keel-block samples were presumed to be as sound as it is possible to cast specimens in a sand mould and so attention was devoted to the casting of small chilled samples. It seemed logical to assume that the best way to obtain information about the gas content of liquid metal was to take a small rapidly-cooled chill-cast sample. By such a procedure the gas content might not be expected to change greatly on cooling. It can further be argued that it is the gas content of the liquid metal which primarily determines the properties of the casting and that changes in gas content on slow cooling after solidification in a sand mould are somewhat irrelevant.

TABLE IV.—*Reproducibility of Results from Chill-cast Samples.*
Chemical Composition, per cent.:—
T.C. 3.48; Si 1.45; Mn 0.54; S 0.088; P 0.099.

Sample No.	Oxygen p.p.m.	Hydrogen p.p.m.	Nitrogen p.p.m.
G.50/1	18	1.1	17
/1	14	1.0	30
/1	17	0.9	24
/2	15	1.3	30
/2	18	0.9	31
/2	19	1.2	31
/3	18	1.1	40
/4	14	1.5	44
/4	13	1.0	32
/4	16	1.5	41
/5	15	1.7	43
/5	15	0.9	26
/6	15	1.5	39
/7	17	0.8	28
/8	18	0.8	27
/8	15	1.1	31
/9	17	0.9	29
/9	17	1.4	36
/9	16	1.3	35
/10	78	1.0	39
/10	15	1.3	39
/11	17	1.4	38
/12	17	1.6	36
/13	17	1.8	37
/14	19	1.3	36
/15	15	1.5	39
/16	15	2.2	33
/17	19	1.8	43

Experience showed that all types of small chilled samples gave very similar results for gas content and finally an open-topped graphite mould, as illustrated in Fig. 7, was used. This mould gave three cylinders 1½-in. long by ⅞-in. dia., and has been used for all subsequent work at the B.C.I.R.A. Reproducibility tests were carried out. Seventeen sets of chilled samples were cast in succession and the gas contents obtained are indicated in Table IV. Ignoring the obviously erroneous results for sample G.50/10, the reproducibilities were 16 ± 3 p.p.m. for oxygen, 1.5 ± 0.7 p.p.m. for hydrogen, and 35 + 9 − 11 p.p.m. for nitrogen. A comparison of results on sand-cast and chill-cast samples is given in Table V.

It can be seen that grey irons when sand cast give higher oxygen results than chill cast samples, but white sand-cast irons tend to give lower results than chill cast samples. As a result of these investigations it was decided that the taking of chill-cast samples provided a practicable means of sampling for the study of the gaseous-element contents of industrial irons and also for the investigation of the specific effects of the gaseous elements.

GASEOUS-ELEMENT CONTENT OF VARIOUS INDUSTRIAL MELTS

Using the small chill-cast sample, Bach[3] has sampled metal at a number of diverse plants including normal cold-blast cupolas, hot-blast cupolas, pulverized-fuel-fired air-furnaces, oil-fired rotary furnaces, cupola/electric furnace duplexing, the basic cupola and blast furnaces. Comprehensive details were taken and have been recorded.[8] A summary of some of the results obtained is given in Table VI; for full details reference should be made to the original paper.

It was felt that the results permitted the following conclusions for the plants examined:

(1) There are significant differences in oxygen and nitrogen contents according to the composition of the iron and the melting unit. Oxygen contents of between 0.0004 and 0.010 per cent. (4 and 100 p.p.m.) and nitrogen contents of between 0.0015 and 0.0140 per cent. (15 and 140 p.p.m.) have been recorded.

TABLE V.—*Comparison of Oxygen, Hydrogen and Nitrogen Contents of Chill-cast and Sand-cast Samples (Gaseous Elements in p.p.m.).*

Ref. No.	Type of iron.	Sand-cast.			Chill-cast.			Composition, per cent.					
		O	H	N	O	H	N	T.C.	Si	P	Mn	S	Mg
G.16	Grey	20	1.2–3.0	18	5	1.0	15	3.8	1.9	0.08	0.7	0.03	
G.19	Grey	35	2.0	10	8	1.9	12	4.0	1.9	0.06	0.8	0.03	
G.33B	Nodular ..	2	1.7	32	2	0.8	34	3.3	2.0	0.05	0.5	0.02	0.08
G.40	Grey	15	0.4	43	6	0.8	43	3.2	1.4	0.12	0.6	0.06	
G.43	Grey	23	0.9	59	12	0.8	50	3.3	1.3	0.13	0.5	0.10	
G.20	White	32	1.8	55	49	1.1	61	1.9	1.4	0.04	0.7	0.04	
G.32	White	55	1.4	20	68	1.8	17	3.2	0.1	0.04	Nil	0.03	
G.34	White	16	1.7	46	28	1.3	51	3.0	0.1	0.04	0.2	0.03	

(2) It appears that the highest oxygen and nitrogen contents are obtained in cupola melting, although high oxygen and nitrogen contents are not necessarily obtained in this way. High oxygen and nitrogen values may be due to the intimate contact of metal and blast in this furnace.

(3) In cupola-melted iron, high oxygen and nitrogen contents are obtained more easily the lower the silicon and/or carbon contents.

(4) The use of hot blast in the cupola does not necessarily give higher oxygen or nitrogen contents than are obtained with cold blast.

(5) The oxygen content of acid, cold-blast

TABLE VI.—*Summary of Bach's Results on Gas Content of Various Types of Irons.*

Sample No.	Oxygen, p.p.m.	Hydrogen, p.p.m.	Nitrogen, p.p.m.	Composition, per cent.							
				T.C	Si	Mn	S	P	Al	B	Ti
Pulverized-co al-fired air- furnace—C hilled rolls.											
1/1	17	1.3	28	3.27	0.84	0.34	0.114	0.52			
1/2	9	1.1	25	3.21	0.82	0.32	0.123	0.50			
1/3	7	1.2	25	3.15	0.82	0.30	0.127	0.50			
1/4	7	1.4	23	3.18	0.79	0.31	0.123	0.51			
1/5	6	1.4	23	3.12	0.80	0.29	0.120	0.51			
1/6	8	1.7	22	3.12	0.79	0.31	0.122	0.51			
1/7	11	1.9	24	3.12	0.83	0.30	0.123	0.50			
Oil-fired rota ry furnace— Malleable c ast iron.											
1st Test.											
2/1	32	1.6	59	3.06	0.59	0.32	0.103	0.088	<0.01		
2/2	20	1.4	56	—	—	—	—	—	<0.01		
2/3	17	1.5	59	—	—	—	—	—	<0.01		
2/4	15	1.5	52	—	—	—	—	—	Nil		
2/5	20	1.3	56	—	—	—	—	—	<0.01		
2/6	20	1.6	51	3.07	0.60	0.32	0.108	0.080	<0.01		
2nd Test.											
3/1	8	1.1	59	3.05	0.66	0.42	0.112	0.080	n.d.	n.d.	n.d.
3/2	5	1.0	51	3.08	0.65	0.41	0.103	0.081	n.d.	n.d.	n.d.
3/3	5	0.8	60	3.06	0.67	0.41	0.109	0.084	n.d.	0.002	n.d.
3/4	5	1.1	55	3.08	0.69	0.40	0.107	0.085	n.d.	n.d.	<0.01
3/5	9	0.9	57	3.02	0.65	0.39	0.108	0.081	n.d.	n.d.	<0.01
Sesci rotary f urnaces—Bl ackheart ma lleable cast iron.											
4/1	8	1.0	74						Trace		
4/2	10	0.9	73	2.26	1.29	0.34	0.119	0.049	,,		
4/3	13	0.9	56						,,		
5/1	12	1.2	70						Trace		
5/2	18	1.2	70	2.13	1.02	0.33	0.108	0.044	,,		
5/3	15	1.2	69						,,		
6/1	11	1.0	69	2.13	1.04	0.32	0.111	0.047	Trace		
6/2	18	1.2	73						,,		
Hot-blast cup ola— White heart mallea ble iron.											
1st Test.											
7/1	30	1.6	121	2.86	0.59	0.37	0.241	0.111	Trace		
7/2	31	1.7	115	2.88	0.56	0.37	0.242	0.109	,,		
7/3	40	1.7	125	2.85	0.49	0.34	0.244	0.111	,,		
7/4	45	1.8	142	2.80	0.48	0.34	0.242	0.112	,,		
7/5	52	1.9	125	2.93	0.52	0.34	0.231	0.108	n.d.		
7/6	47	1.8	118	2.81	0.53	0.34	0.229	0.110	n.d.		
2nd Test.											
8/1	28	1.0	114	2.96	0.66	0.38	0.196	0.072	<0.01		
8/2	28	1.0	117	2.75	0.52	0.36	0.191	0.082	<0.01		
9/1	23	1.3	111	3.29	0.72	0.39	0.190	0.086	<0.01		
9/2	24	1.5	120	3.10	0.68	0.38	0.197	0.082	<0.01		
9/3	23	1.4	117	3.09	0.61	0.40	0.224	0.082	<0.01		
9/4	28	1.6	112	2.98	0.59	0.34	0.205	0.086	<0.01		

B and Ti contents were determined spectro-graphically; n.d. = not detected spectrographically.

cupola metal can differ in plants producing iron of similar compositions.

(6) Irons of similar compositions may have widely differing oxygen and nitrogen contents according to the melting process.

(7) The oxygen content of metal from a melting unit may vary from day to day.

(8) The oxygen and nitrogen contents of pig-irons can vary considerably, but are of the same order as those obtainable in cast irons.

No conclusions were drawn about variations in hydrogen content. No significant variation was detected, but it may be argued that vacuum fusion is not best suited to the determination of hydrogen in cast irons. Hydrogen is known to be evolved from samples on standing at room temperature and of necessity some samples had to be stored before they could be analysed. Furthermore, the hydrogen obtained by vacuum fusion of cast irons is but a small part of the total gas evolved, so the method is not particularly sensitive.

Almost simultaneously with the publication of these results by Bach,[3] the results of a similar investigation in Germany[26] were made available. These investigators studied the oxygen and nitrogen contents of various hematite pig-irons in relation to the oxygen and nitrogen contents of malleable and grey irons produced from them and melted in cold-blast and hot-blast cupolas and in pulverized-fuel-

TABLE VI (*contd*).

Sample No.	Oxygen, p.p.m.	Hydrogen, p.p.m.	Nitrogen, p.p.m.	Composition, per cent.								
				T.C	Si	Mn	S	P	Al	Ti		Cr
Cold-blast cupola—Blackheart malleable iron.												
10/1	104	1.1	103	2.79	0.58	0.35	0.137	0.042				
10/2	84	1.0	101	2.84	0.58	0.35	0.141	0.044				
10/3	64	1.1	102	2.91	0.64	0.39	0.137	0.043				
Duplexed electric furnace—Blackheart malleable iron.												
11/1	14	0.9	100	2.72	0.93	0.40	0.136	0.040				
Pulverized-fuel-fired air furnace—Blackheart malleable iron.												
12/1	10	1.6	89	2.53	0.92	1.05	0.114	0.067				
12/2	9	1.3	90	2.45	0.93	1.09	0.112	0.063				
Hand-fired air furnace—Blackheart malleable iron.												
13/1	7	1.5	75	2.48	0.96	0.35	0.088	0.074				
13/2	7	1.4	74	2.32	0.95	0.35	0.089	0.070				
Cold-blast cupola—Automobile castings.												
15/1	6	1.0	58	3.53	2.34	0.70	0.110	0.34				
15/2	6	1.1	60	—	—	—	—	—				
15/3	5	1.3	60	—	—	—	—	—				
15/4	6	1.3	63	3.35	2.22	0.74	0.115	0.34				
Water-cooled cold-blast cupola—Automobile castings.												
16/1	26	1.1	65	3.13	2.33	0.79	0.089	0.095				.23
16/2	21	1.5	61	—	—	—	—	—				0.27
16/3	23	1.5	55	—	—	—	—	—				0.32
16/4	23	1.8	57	3.25	2.35	0.81	0.076	0.102				0.29
16/5	20	1.7	68	—	—	—	—	—				0.20
16/6	17	1.6	66	3.26	2.15	0.82	0.089	0.110				0.20
16/7	15	1.7	62	—	—	—	—	—				0.21
16/8	14	1.6	57	3.34	2.51	0.97	0.087	0.110				0.18
Cold-blast cupola 42 in .dia.—Grey-iron castings.												
17/1	6	1.2	51	3.29	2.13	0.80	0.115	0.33				
17/2	5	1.3	52	3.35	2.11	0.73	0.119	0.33				
17/3	6	1.3	61	3.34	2.17	0.82	0.120	0.32				
18/1	5	1.2	57	3.28	2.09	0.85	0.120	0.32				
18/2	5	1.2	56	3.28	2.18	0.82	0.106	0.33				
18/3	5	1.2	54	3.29	2.09	0.85	0.095	0.32				
									Cu	Al	Ti	
Acid-lined cupola—Automobile castings.												
19/1	10	1.1	70	3.40	2.27	0.90	0.098	0.14	0.20	n.d.	0.04	<0.03
19/2	14	1.2	50	3.35	2.41	0.86	0.097	0.15	0.18	n.d.	0.07	<0.03
									Cu	Al	Ti	V
Duplexing arc furnaces												
20/1	8	1.4	68	3.27	2.42	0.70	0.107	0.16	0.16	n.d.	0.07	<0.03
20/2	10	2.0	68	3.28	2.45	0.69	0.109	0.16	0.15	n.d.	0.07	<0.03
									Cr	Ni		
Acid cupola—Piston rings.												
21/1	6	0.9	41	3.38	2.05	0.78	0.121	0.57	0.37	0.06		
Duplexed in direct-arc furnace—Piston rings.												
22/1	13	1.4	41	3.18	2.28	0.70	0.122	0.53	Cr 0.48	Ni 0.12		
22/2	11	1.2	42	3.21	2.19	0.60	0.120	0.54	0.47	0.12		

n.d. = not detected spectrographically.

fired rotary furnaces. Some of the oxygen figures quoted for the pig-irons are very high and raise the question of the effect of sampling technique. On the other hand, the oxygen and nitrogen figures given for the resulting cast irons are similar to those reported by Bach, but they all tend to be high. The oxygen content of the rotary-furnace metal appeared to be somewhat lower than that of the cupola metal. Further, the results appeared to show a slight tendency for the oxygen content of the iron to increase with the iron-oxide content of the slag in cupola melting, and to decrease with increasing pouring temperature and increasing silicon content, but in all cases there was considerable scatter. The iron-oxide content of rotary-furnace slag did not appear to influence the oxygen content of the resulting cast iron.

The German investigators also produced figures to show a reduction in oxygen content after late additions of ferro-silicon and aluminium and they imply that the improvements in casting quality (soundness) arising from late additions of deoxidizers arise from the reduction in oxygen content. However, they did not find this reduction in oxygen content when the iron only had 0.002 to 0.004 per cent (20 to 40 p.p.m.) oxygen before treatment. Many oxygen contents in British irons were found by Bach[3] to fall within this low range. The comments of the German investigators imply that treatment with ferro-silicon and aluminium gives sounder castings due to oxygen elimination, but this claim requires careful checking.

Obviously much further work is required on the gas content of industrial melts, on the effect of late additions and on the relation of gas content of the metal-to-slag composition, and pig-iron used.

(To be continued)

TABLE VI—*(contd.)*

Sample No.	Oxygen p.p.m.	Hydrogen p.p.m.	Nitrogen p.p.m.	Composition, per cent. T.C	Si	Mn	S	P				
Hot-blast cupola—Spun pipes.												
1st Test.												
23/1	5	0.9	11	3.52	2.13	0.31	0.077	1.06				
23/2	5	0.8	13	3.52	2.09	0.31	0.077	1.03				
23/3	5	0.9	13	3.53	2.18	0.31	0.076	1.01				
2nd Test.												
24/1	6	0.8	16	3.46	2.16	0.33	0.123	0.78				
24/2	7	0.8	16	3.47	2.22	0.33	0.112	0.75				
24/3	6	0.8	14	3.51	2.16	0.32	0.088	0.75				
24/4	7	0.9	17	3.41	2.34	0.37	0.098	0.84				
24/5	7	0.8	15	3.42	2.32	0.34	0.071	0.80				
Cold-blast cupola—Spun pipes.												
25/1	5	1.0	20	3.52	2.38	0.40	0.064	0.76				
25/2	4	1.0	18	3.64	2.22	0.40	0.055	0.76				
Cold-blast cupola—Cylinder liners.									Cr	Ni		
26/1*	12	1.0	52	3.28	2.10	0.61	0.124	0.99	0.38	0.13		
26/2†	9	1.5	32	3.23	1.99	0.59	0.074	1.00	0.39	0.09		
* Before desulphurizing. † After desulphurizing.												
Blast furnace—Pig-iron.												
27/1	4	1.5	25	3.99	3.30	0.48	0.027	0.59				
27/2	15	1.5	40	4.02	3.20	0.48	0.034	0.60				
27/3	5	1.4	44	4.05	2.56	0.45	0.039	0.60				
27/4	11	1.2	46	3.97	2.75	0.47	0.039	0.60				
27/5	8	1.6	18	3.92	2.01	0.47	0.037	0.60				
Blast furnace—Pig-iron.									Ni	Ti	V	
28/1	7	1.9	77	3.64	2.12	1.33	0.039	1.12	0.03	0.10	0.13	
28/2	10	1.4	72	3.77	2.07	1.45	0.030	1.13	0.04	0.13	0.11	
29/1	7	1.7	95	3.22	1.25	0.94	0.157	1.32	0.04	0.05	0.15	
30/1	8	2.7	96	3.37	0.96	0.92	0.184	1.26	0.03	0.05	0.15	
30/2	11	2.0	105	3.37	1.00	0.95	0.172	1.18	0.03	0.05	0.13	
31/1	6	1.5	36	3.88	1.85	1.54	0.025	1.31	0.03	0.10	0.13	
31/2	5	1.1	44	3.87	1.86	1.52	0.026	1.27	0.07	0.10	0.12	
Rocking-arc furnace—Austenitic castings.									Cr	Ni	Cu	
32/1	4	0.9	110	3.03	2.20	0.67	0.075	0.25	2.88	12.6	5.16	
Induction furnace—Heat-resisting castings.									Cr	Ni		
33/1	120	5.2	1,800	1.71	1.52	0.39	—	0.11	31.2	0.25		
33/2	120	6.6	1,700	1.47	1.47	0.36	—	0.11	30.8	0.26		
Basic-lined cupola—Malleable iron.									Cu	Al	Ti	V
34/1	31	1.3	125	2.77	1.68	0.43	0.073	0.062	1.01	<0.01	<0.01	<0.03
34/2	19	1.3	111	2.95	2.26	0.45	0.074	0.066	1.06	<0.01	<0.01	<0.03
Electric-furnace duplexing—Malleable iron.									Cu	Al	Ti	V
35/1	43	2.0	94	1.28	2.03	0.47	0.058	0.065	1.10	0.06	n.d.	n.d.
35/2	35	1.8	80	1.32	1.98	0.45	0.052	0.060	1.08	0.06	n.d.	n.d.

Nuclear Energy Committee

With the object of stimulating interest in metallurgical problems arising in connection with the industrial and scientific aspects of the use of nuclear energy, the Council of the Institute of Metals has appointed a Nuclear Energy Committee. It is proposed that, among its activities, the new committee shall arrange special meetings, discussions, and symposia; invite the writing of papers or articles for publication; and arrange the publication of books or other literature to attain the objects for which it was formed. The committee hopes to arrange an exhibition of nuclear energy products, of interest to metallurgists, in connection with the Institute's spring meeting in April next year.

The constitution of the committee is:—Mr. G. L. Bailey, of the British Non-Ferrous Metals Research Association; Mr. E. W. Colbeck, a director of Hadfields, Limited; Dr. Maurice Cook, joint managing director of the metals division of Imperial Chemicals, Limited, and current president of the Institute; Dr. S. F. Dorey, chief engineer and surveyor of Lloyd's Register of Shipping, a past-president of the Institute, and a member of the Iron and Steel Institute; Dr. H. M. Finniston, of the UK Atomic Energy Authority; Dr. Ivor Jenkins, of the General Electric Company, Limited; Prof. A. G. Quarrell, Professor of Physical Metallurgy and Dean of the Faculty of Metallurgy at Sheffield University; Mr. L. Rotherham, of the UK Atomic Energy Authority; Mr. S. S. Smith, of the metals division of ICI; and Major P. L. Teed, of Vickers-Armstrongs (Aircraft), Limited.

Industrial Expansion in Ulster

Confidence that within a reasonable time and with the assistance of the Northern Ireland Government the back of the unemployment problem in the region could be broken was expressed in Belfast on December 7 by Lord Chandos, chairman of the Northern Ireland Development Council. Lord Chandos revealed that the British Thomson-Houston Company, Limited, of which he is chairman, was considering setting up a new works in Ulster. The company has a large project at Larne (Co. Antrim) and is now giving thought to the establishment of a new plant in a different section of its activities which would be self-contained, and would employ permanently about 2,500 people.

Lord Chandos stressed the advantages to be gained by the incoming industrialist. There was plenty of labour, while the rest of the UK was desperately short of labour. The great difficulty about getting industrial sites did not exist in Northern Ireland. They were desperately short of industrial capital and the more Mr. Butler applied his credit squeeze in the UK the easier it was going to make the task in Northern Ireland.

Production Exhibition and Conference, 1956

The biennial production exhibition and conference will be held in the Grand Hall, Olympia, London, from May 23 to 31, 1956. The exhibition will demonstrate the science of productivity, and exhibitors will show ways in which research can be applied to production, or ways in which increased productivity has been achieved in their own works or in the works of other manufacturers. The conference, organized by the Institution of Production Engineers, which is to run concurrently with the exhibition, will develop the theme "Investing in Success." The exhibition organizer is Andry Montgomery, Limited, 32, Millbank, S.W.1.

Heat Limitations of Gas Turbines

Marine gas turbines at present under development for marine propulsion purposes are of open-cycle type, in general, the H.P. turbine driving an axial compressor as an independent unit, the L.P. providing the useful output and exhausting through a heat exchanger which preheats the inlet charge to the combustion chamber.

The designs vary considerably, but can be considered in two main categories, stated Dr. S. F. Dorey, in the course of his presidential address to the Engineering Section of the British Association at the Bristol meeting in September. The first covers those of lightweight construction, under 7 lb./h.p. and developing up to 6,000 s.h.p. The H.P. inlet temperatures of about 820 deg. C. limit the life of the hot parts to little more than 1,000 hrs. Units of this type power light naval craft only. A satisfactory life in excess of 20,000 hrs. is required for the main engines of merchant ships. This is at present obtained by limiting the top temperature to below 700 deg. C. in medium-weight plants of 25 to 30 lb./s.h.p. Both classes of gas turbine have overall efficiencies of about 20 per cent., but when the long service reliability of the latter has been established, advances in top temperatures and design should provide fuel consumptions below 0.5 lb./s.h.p. hr. Since these engines cannot be run astern, either electric transmission, reversible pitch propellers or reduction gearing with reverse trains must be used. Of these, the last quoted is receiving the greatest attention and is likely to predominate in future installations.

English Electric's US Contracts

Four 40,000-kva, single-phase transformer are to be built at the Stafford works of the English Electric Company, Limited, following the award of a contract worth $450,000 from the Tennessee Valley Authority to the English Electric Export & Trading Company, Limited. This is the first tender that the authority has accepted from the company; it was about $350,000 lower than the nearest United States bid and underbid two foreign tenders.

English Electric also announces that the United States Army Corps of Engineers has awarded a contract for the manufacture and delivery of a 90,750/121,000-kva, 13.2/161-kv, three-phase, 60-cycles power transformer, with all accessories and spare parts, to the export company, which submitted the lowest bid against the first invitation for this same contract. At that time, however, all bids were cancelled and the invitation reissued. The transformer will be installed in the switchyard at Table Rock Dam, located on the White River in Taney County, south-west Missouri, and will serve two generators each rated at 52,632 kva.

Metrovick Team for India

Part of the team of specialists selected by Associated Electrical Industries, Limited, to advise the Indian Government on the setting up of a heavy electrical manufacturing industry has already left for India. AEI has received a 15-year contract to act as consultants for the project.

The party consists of experts from the Metropolitan-Vickers Electrical Company, Limited, and is led by Mr. A. Paterson, assistant works manager at Trafford Park.

Ingates*

Congress Discussion of TS 24 Sub-committee Report

Comment on this report was mainly criticism that it fell between the "two stools" of research and practice—a view with which one of the members of the sub-committee agreed. Individual queries were posed concerning streamlining of ingate and runner systems, places where the report appeared to be ambiguous, the different effects of turbulence in a running system, pouring methods, effect of bends and ingate-area ratios. Representatives from the sub-committee explained the attitude which had been adopted, particularly in the way the terms of reference had been construed. Ancillary matters discussed were speeds of metal flow and aspirated air in the gating systems; the single written contribution postulated the use of nomograms for presenting the data in a practical fashion.

At the final session of the International Foundry Congress held in London, Mr. H. J. V. Williams, who occupied the Chair jointly with Mr. Vuilleumier, called on Dr. G. Martin to present the report of technical sub-committee TS 24 of the Institute of British Foundrymen on Ingates, mentioning that he was one of the members of the sub-committee.

DR. MARTIN, in introducing the report, stated that the principal aim of the sub-committee had been to demonstrate that the basic principles of hydraulics could be applied to the problem of gating of castings, provided that certain assumptions were made, and also to indicate that the application of such principles led to an improvement both of the casting yield and the casting quality. The assumptions which had to be made were concerned with the nature of the viscosity of molten metals or alloys and their surface-tension. Provided metal was sufficiently superheated above its liquidus or melting point to be practicably pourable, then the viscosity change within the comparatively small temperature range occurring in practice could be neglected. This assumption of course failed if the alloy or metal temperature approached the liquidus or melting point, but in this case one was not likely to get a good casting. Regarding surface tension, it was important to realize that molten metals or alloys generally did not wet the mould. This meant that gating experiments performed with water, which wets an experimental mould unless special precautions are taken, must be treated with some circumspection. An example was given in the report.

Application

The extent to which the suggestions made by the sub-committee were of use in a foundry depended very much on the type of foundry concerned. For this purpose, foundries could be divided according to the type of metal cast—that is, dross-forming, such as aluminium, or non-dross-forming, such as cast iron—or according to the production method employed. In the case of dross-forming metals, it was imperative that the metal be led into the mould as quietly as possible and any aspiration of air avoided. This required that the gating system be streamlined as much as possible. There were many different ways in which this could be carried out, but the most efficient method could be found by comparing the loss-coefficients of the various methods possible. If experimental conditions, such as the alloy composition, temperature, etc., were standardized, then the system having the lower loss-coefficient was more streamlined and therefore least likely to cause turbulence.

Air Aspiration

There were two possible mechanisms of air aspiration, *i.e.* two ways in which air could be introduced into the mould: the first occurred if the pressure at any stage of the gating system dropped below atmospheric and the mould material was permeable, in which case air was sucked through the mould into the metal stream; the Bernoulli equation given on page three of the preprint of the report enabled one to calculate flow velocities necessary at any part of the gating system so that pressure remained atmospheric throughout and the danger of that type of aspiration was avoided. The second method by which air could be introduced into the mould was through vortex action in the downgate. It could be completely avoided by the use of a runner bush to ensure that the downgate was always full.

In the case of non-dross-forming metals or alloys, the problem of streamlining the gating channels was of less importance from the point of view of obtaining a clean casting. Here the endeavour was to allow "dirt" to settle out by the inclusion of dross-traps or intermediate expansion of the gating channel. Provided the rate at which dirt, etc., floated to the surface in any given alloy was known, the equations given in the report enabled one to calculate the minimum size of gating channels required for the complete removal of dross by flotation.

Calculations

In addition to this question of clean metal, the work of the sub-committee indicated a method of calculating the shape of a gating system such that the maximum yield was obtained for any desired pouring rate.

Maximum yield was obtained if each section of the gating system passed, and just passed, the metal delivered to it by the preceding section. An example

* Report printed in the JOURNAL, December 15.

of such a calculation was shown in Appendix III.

The importance of yield and the saving that could be obtained by a change of gating method depended on the production method in use at any particular foundry. In a jobbing foundry, for instance, producing castings of several tons weight, the yield was generally very high and a saving obtained by reduction in size of parts of the gating channels was generally negligible. Similar considerations applied to the steel foundry, where a lower yield was due to the large size of feeders used and gating channels were generally very small compared to the size of the casting with the feeders. Quite different was the case in a mechanized or semi-mechanized foundry; here, small savings in the yield of each casting multiplied rapidly, and particularly if the work consisted of small castings, several in a box, a very considerable increase in yield could be expected by submitting the gating system to the detailed calculations shown in the report. Two further aspects of yield were brought out in the report: the shape of the downgate and the effect of streamlining. Downgrates should be tapered downwards, a measure which could be effected on moulding machines easily, with a spring-loaded peg pattern. An indication of the saving in yield that could be made with a streamlined gating system, as compared with one containing all sharp angles, was shown in the report; it might be as much as 50 per cent.

DISCUSSION

Opening the discussion, Mr. M. Vuilleumier, (president of the Swiss Foundries Technical Committee), said all knew how difficult is was to get a good ingate for it depended very much on the size of the casting. When considering at one time very small castings along with very big ones—twenty tons or so—it was not easy to get correct ingates. The report gave invaluable instruction on how to go about such matters. He was very pleased to open the discussion and to thank Dr. Martin and the sub-committee for this work on ingates.

Practical Criticism

MR E. M. CURRIE regretted that all he could do was to "damn" the report "with faint praise." It seemed there had been a good deal of careful work done, but unfortunately too many factors had been ignored, or glossed over, which did materially affect the castability or flowing power of metal. Also, there seemed to be too many assumptions on which the formulae given were based. For example, on page two of the preprint it was stated that the general laws of hydraulics could always be applied to gating systems of metal. This was an assumption which could not always be applied to ingates of very complex shape often met with in the foundry. Then again, Dr. Martin had said that the rate of flow was "very little affected" by metal temperature and sand moisture-content within the limits of normal working practice. From the ordinary practical point of view those two points as stated were not true. Further, on preprint pages eight and nine there appeared a considerable number of "excuses," which he thought rather tended to invalidate a number of the points which had been made.

He did not want to comment in critical detail throughout the report, but would suggest to the sub-committee that they should do some more work on the subject and should co-opt to their membership a few more from the foundry "floor" because there was no doubt that one of the most important factors in producing good sound castings in any metal was as complete a knowledge of the subject of ingates as could possibly be obtained. He felt, however, that if all the literature on gating written during the past 20 to 30 years was unsuitable for a general foundry foreman to apply it with commonsense and experience to get successful results, he (the foreman) had certainly not got the time to settle down to studying mathematics on the subject.

DR. MARTIN said Mr. Currie's remarks reflected the opinion of some members of the sub-committee; if he would study the composition of the sub-committee he would see that it was composed mainly of practical and senior foundrymen. The question of mathematics had been discussed at great length and the present report was a compromise between a mathematical treatise and a completely empirical approach. The sub-committee had received instructions from the Technical Council of the Institute to conduct the approach to their subject along fundamental lines, using basic principles, they could not do anything but obey these instructions.

As far as foundrymen were concerned, any algebraic equations were complicated; there was no royal road to good foundry practice and if one wanted the most efficient gating system, then one had to do some algebra. With regard to what was already available, there were not many data to suit complex sections, but as most of the shapes were simple curves and bands for which data existed, hydraulic theory could be used to a large extent.

As to sand moisture, the sub-committee had experimented and had found that it did not affect pouring time provided other factors were kept constant. Pouring temperature within practical ranges likewise did not affect pouring times. If for any reason, such as a high rate of heat-extraction, the temperature of the metal fell to near the liquidus or melting point, then of course the loss-coefficients would change.

Streamlining

DR. R. V. RILEY said he would like to raise one or two minor criticisms. He had not studied the report in great detail, but there were two assumptions in it which he would like to question. Was it established that a streamlined metal flow was desirable or practical in ordinary foundry moulds? To be certain that during the experiments a streamline flow existed, it was surely necessary to decide what was the critical rate of flow at which a change from streamline conditions to turbulent conditions took place. Secondly, was it ever going to be practical in an ordinary sand mould to keep out air, because when working with a permeable sand mould he was sure air would be drawn in at every turn and bend wherever the pressure dropped for

any reason. Furthermore, in any running system, sudden changes in direction were deliberately arranged in order to separate dross and slag and collect them at strategic points before the metal entered a mould. Had this point been adequately considered?

DR. MARTIN replied that the streamlining of a gating system did not necessarily give a streamlined laminar flow. He did not believe laminar flow was ever attained in a gating system. Possibly, a notable exception was a small feeder-gate or a strainer-gate, but that had not been investigated. In ordinary gating systems no laminar flow ever occurred; streamlining merely meant reducing the turbulent conditions of flow in ordinary foundry moulds, which included anything from the moulds for small castings to moulds for 50-ton castings. The question of air aspiration had been dealt with at some length in the report; suitable selection of cross-section for the ingate prevented air aspiration even in a permeable mould.

Whether changes of direction brought out dross was a point on which many foundrymen would argue. He doubted very much whether turbulence of the stream would bring out dross; it was more likely to create more. The whole art of dross elimination in non-dross-forming metals was to allow the material to float to the surface, to put on a skim gate or restriction gate across the ingate of the mould and then let the clean metal flow underneath. There was a possible way of calculating the size of channels required for such dross elimination, provided the size and density of the dirt particles were known.

An Important Field

MR. R. W. RUDDLE thought all would agree that consideration of ingates was a field of the highest importance because so many defects in castings could be traced to the way in which metal was introduced into the mould. Indeed, some authorities suggested that as much as 50 per cent. of casting defects were due to that cause. He wished therefore to emphasize the importance of the work of the sub-committee and congratulate them on the very careful study made of many aspects of that exceptionally difficult subject. It was a most complicated problem and the sub-committee must have had to face great difficulties, particularly when preparing their report.

Turning to the actual report, he had to confess that like the previous speakers he had had a feeling of disappointment. In his opinion, the report rather fell between two stools. In the first place it was an account of research and described the results of some original and, he thought, most useful work. On the other hand, it was instructional report, the purpose of which was to enable practical foundrymen to apply scientific methods to the design of gating systems. He did not feel that either purpose had been adequately fulfilled. The sub-committee had done much useful work, but they had not done themselves justice in their report.

Referring to the instructional aspect, he thought it insufficient guidance to a foundryman to present him with a number of examples in an Appendix, which was in fact all that had been done. Dr. Martin's introduction was much more helpful than the report itself, from this point of view.

Ambiguity

Turning to the scientific side, the sub-committee had carried out a large number of experiments with a view to determining the hydraulic loss-coefficients applicable to different parts of gating systems and those results were summarized on page eight of the preprint. However, it appeared from the text that the figures given were not entirely based on the experiments conducted by the sub-committee, but were to some extent drawn from literature on the subject and other sources; it was not quite clear, therefore, how far the sub-committee's own work had contributed to the figures. For instance, on page five, the determination of the loss-coefficient for a direct, top-gate was described in detail and a coefficient of 0.72 was found. But that did not appear to match up with some of the figures on page eight where the coefficient was stated to be 0.1 to 0.2 for a rounded entry and 0.75 to 1.0 for a sharp entry. The report should have given much more detail of the experimental results (if necessary in an Appendix) and have indicated precisely how the loss-coefficients were derived, how reproducible they were and how far the sub-committee's own results were used in compiling the figures on page eight. He asked the sub-committee to consider publishing a more detailed report on that particular aspect of the work.

Turbulence

Turning to a point which Dr. Martin had raised in the discussion and which was mentioned in the preprint of the report on page 10, namely the question of turbulence in a gating system, he thought it necessary to distinguish between two types of turbulence—an undesirable kind and a kind which did not very much matter from the point of view of gating. It was possible for metal to flow in a turbulent fashion along a tube and provided no separation from the walls of that tube occurred there was no reason to suppose that the turbulence would be harmful from the aspect of gating. On the other hand turbulence was often accompanied by separation of material from the walls of the tube—this was especially prone to occur at bends, section changes, etc.—and in this event air would be drawn into the system ; a large metal surface would be exposed to this air, oxidation would take place and copious amounts of dross might form. He thought the difference between these two kinds of turbulence should be clearly understood. The overall loss-coefficient K of the gating system, which was referred to in the report, was a measure of the total turbulence, *i.e.* of both kinds of turbulence. What the foundryman wanted was a measure of the undesirable turbulence, and therefore it was not quite true to state, as it did in the report, that the coefficient K was a measure of the efficiency of the gating system, or a measure of the production of dross in the gating system. He suggested to Dr. Martin that

in, for example, a pencil gating-system where the metal flowed through relatively long, thin channels, there would be considerable wall-frictional losses so that the overall loss-coefficient would be high, but that this would not necessarily indicate that much turbulence of the undesirable kind had occurred.

Dr. Martin agreed that the comments were fully justified. The first point was quite correct, the report did fall between two stools. It was a compromise between research and practical information, but he knew of no method of overcoming that save by publishing two reports, which the sub-committee could not undertake to do. The publication of a more detailed report depended entirely on the instructions they received from the Institute's Technical Council.

About 800 to 900 individual experiments had been performed in the course of that very long work and to have published them all would have made a work of considerable volume; without including any of the work done by the sub-committee it would have been a book of 100 pages, and he doubted whether the Technical Council would have approved such a publication because it was just a mass of detail, none of which was of any use to anyone except to research workers.

The two types of turbulence certainly existed, but would be difficult to distinguish. The factor K included both types of turbulence and he did not quite see how they could be separated, but if the factor K was related to both external and internal turbulence, then surely it was also a measure of external turbulence alone. It was the only method the sub-committee had found of comparing it and he agreed it was not a perfect measure.

Pouring Methods

MR. J. R. BOOTH said he had only one query to raise and that was regarding the actual method of pouring employed; no particulars of this appeared in the case of the examples quoted on page five of the preprint. How was the method of pouring standardized, and had the sub-committee found that such things as the height of the ladle above the runner and the actual speed of the flow through it made any difference, or as much as one would expect? He also expressed mild surprise at the suggestion (on page eight) of the very slight effect on running time of fluidity, as governed by the temperature and the phosphorus content.

He had been very interested in the report, but thought Dr. Martin would agree that it was an extreme simplification of something very complex and he hoped there was a good deal of other work to follow. One thing about which he would like to hear more was the effect of mould material.

Dr. Martin said the method of pouring was generally to have a constant head runner with a bush into the downgate and usually an overflow. That was the most convenient means of keeping the "head" constant. The height of the ladle above the downgate did not seem to matter provided that the jet of metal from the ladle did not go directly into the downgate—it being agreed by the practical men that the latter would represent bad pouring practice in any case, except in the case of steel, where one did pour straight into the downgate. That had been mentioned in the report. As to fluidity: the sub-committee were not talking about fluidity, but about changes of viscosity with temperature. He thought the term fluidity was not mentioned in the report; it was a very complex property and he would not like to discuss it. On the question of mould material: one of the assumptions which had not been stressed in the report, but which was important, was the assumption that there was no heat loss while the metal flowed through the gating system. In the United States, some very useful experiments had been carried out on that subject and it had been found that the temperature loss was not very critical for the usual moulding materials employed, but if heat-flow and hydraulic theory were combined, most complex calculations resulted.

Influence of Bends

MR. H. G. HALL said his one query concerned Appendix I, page 10 of the preprint, where a calculation was given, *Example 1*—he had been quite puzzled over it and hoped that he was not the only one in that respect. An example was quoted and continuing in the same section (under "mould data") a bend of 120 deg. was included and on the other side there was a very high loss-coefficient. It was necessary to examine that very carefully to decide that it was not the 120 deg. bend which caused the loss-coefficient, but the reduction in area from A1, 0.6, to A3, 0.258. Unless that was carefully studied, the average practical foundryman would tend to assume there was a fundamental error. The ingate was bent through 120 deg. and the loss-coefficient was given as five or six times what it was for the ingate area. That should be more emphasized, for it seemed to be closely connected with the bend.

The practical foundryman, he thought, might easily take up the question of the shape of the downgate and decide to experiment rather with the facts brought out in Fig. 6. Such further work might follow in part some of the practical work that the speaker had done himself some 12 months or so ago, bearing in mind also that such a shape could be arrived at by the use of rubber or spring-loaded downgate formers. At his own foundry they changed to the spring-loaded downgate former and every one was very satisfied until suddenly it was found that the percentage yield of good castings to metal poured per week was slowly going down. The answer was a simple one—in making a very elaborate rubber downgate former the whole downgate was made some half a pound heavier than normal, and with 20,000 downgates per week it represented a considerable increase in metal melted.

DR. MARTIN apologized for the drawing on page 10 of the preprint, on which the 120 deg. angle was misleading. It had not been made clear that the metal descended and then turned back very slightly.

MR. HALL interrupted to say he thought it was the loss in area which was giving the lower co-efficient rather than the 120 deg. bend.

DR. MARTIN, continuing, explained that actually in a bend if one reduced the area the loss-coefficient was reduced. That was one of the general principles of hydraulics, which could be confirmed. If the ingate channel was bent and reduced in area behind the bend, the loss-coefficient was in fact reduced. A downgate of the shape shown in Fig. 6 could be obtained by means of a spring-loaded former pattern. He did not know if Mr. Hall had managed to carry out the calculation of the area, but if the bottom section of the tapered downgate was the same size as the original parallel downgate, there would be a loss of yield. The top of the tapered downgate should be made the same size as the original parallel downgate.

Ingate-area Ratios

MR. K. REINDERS (Holland) wanted to know if the ingate areas were made as shown in Fig. 8, should all the ingate areas be of the same size? He remembered that once he had seen a film* on ingates issued by a German company, in which it was indicated that in such a pouring system (Fig. 8) one should make the ingate area in the end of the runner larger than the ingate area at the beginning of the runner. Due to the friction of the wall of the runner system, the static pressure at the end of the runner would be lower than at the beginning, so that under the conditions recorded for Fig. 8, the amount of metal, flowing into the mould, would be larger through the first ingates than through the ingates at the end of the runner. The effect of changing the ingate areas was to obtain the same mass of metal delivered into the mould through each ingate and in the case of a long mould, to ensure that the metal would have the same running speed at each. Could Dr. Martin elaborate on that point, and had it been considered by the sub-committee?

DR. MARTIN said Fig. 8 was only a schematic example to show how the graded areas should be calculated. It did not necessarily imply that of the shape or proportions indicated. As to kinetic effects: if the runner bar extended beyond the last runner most of the kinetic energy would be absorbed there. Kinetic effects had not been extensively considered, but were important. The general aim was to absorb kinetic energy of the metal stream as much as possible in the pouring dish, at the foot of the down gate and the end of the runner.

A MEMBER, to elaborate the reply to Mr. Reinders, said the point he had postulated regarding the different speed of running in a runner-bar really only applied when the runner-bar was of the same cross-sectional area all along its length. He thought the sub-committee were correct in showing a runner-bar of diminishing area towards the end; it would give equal flow through all the runners.

* Particulars of this film were later supplied to the secretary of the Institute of British Foundrymen. The title is "*Einfache Physikalische Versuche zur Anschnitt und Giesstechnik*"; it was produced by Gebr. Hüttenes K.-G, Dusseldorf-Heerdt, Germany, and it shows very simple physical experiments closely connected with the problems investigated by sub-committee T.S.24.

Limitations of Committee Work

DR. V. KONDIC, a member of the sub-committee, said he would like to reply to some general points. Speakers, he thought, had failed to distinguish between a paper presented by an individual member and a committee report—there was an important difference to be borne in mind when criticizing the two. In the case of an individual paper, members were quite free to criticize the Author on any aspect, but when a committee tackled a problem they had to stick to the terms of reference, and the terms of reference in this case were to study the conditions of metal flow. The sub-committee had found that if they tried to do just that it would take very many years, and the only feasible procedure was to study the rate of metal flow. That had been made quite clear early in their report. It was some general experimental work carried out on those lines that they then tried to explain in terms of basic hydraulics. That, in practice, meant that the report was rather "loose," and what they had done then was to bring out the point that the question of the speed of flow had some bearing on the design of ingates. The sub-committee had never attempted to give guidance on the design of ingates as such.

It might be asked if the report could be made use of as it stood. Some members of the sub-committee had, in fact, made some use of it, and he could assure members that it had been used, and gating systems had been modified according to the principles mentioned, with important results. However, it required some careful consideration on the part of those doing so.

MR. D. FLEMING said, in view of the remarks of Dr. Kondic on the question of using the principles outlined in the report to get better results than were achieved by practical foundrymen, it appeared that that paper did not, in fact, deal with anything but rate of flow in a given gating system. What was the proper speed of flow for a given casting? Was the result identical when applied by a practical foundryman or a man using the calculated downgate system?

One other point was that he could not accept the statement that grey cast iron was a non-dross-forming metal.

Supplementary Matters

DR. MARTIN pointed out that the terms of reference were to report on the rate of flow; the sub-committee could not take notice of any effect on the casting. If they found an improvement in casting quality, it could be reported, but not experimented on. They were confined to flow in the gating system itself; later, no doubt, the effect on the casting could be studied more closely.

Grey iron was not oxide-forming and any dross that existed in it or in the casting was carried in from the ladle or caused by erosion.

MR. FLEMING did not agree with these explanations and suggested that if one attempted to cast a thin-walled cylinder by pouring alternatively from a great height and from a very low position and then examined the two castings there would be found to be a great difference. What he wanted to

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clarify was that only speeds of flow were being dealt with, no attempt was made to show which of the designs would be better for other reasons.

Continuing, DR. MARTIN said it could not be said which rate of flow was best for a given casting, but he thought the information given in the report would allow foundrymen to calculate the best gating system. As to casting speed, all through the report it had been stressed that one of the essential elements was pouring time; once one knew that one could calculate the gating system.

Aspirated Air

MR. J. L. FRANCIS suggested all were interested, primarily, in practical results. What interested him particularly was the possibility of entrained air in a casting due to the use of gating systems in which the total area of the ingate into the mould cavity was in excess of the downgate. Experience had shown that that was a very bad practice, at least for cast iron. It led to trouble, particularly in castings such as cylinders, because one got defects in the walls often attributed to liquid shrinkage, but which he had found was often due to air drawn into the mould with the metal stream. Such aspirated air had got to try to escape, and in many cases the casting solidified before it could do so.

The effects of bad ingate design also applied to plate-like castings of fairly large surface area and they might also be associated with the non-metallic types of inclusions which appeared to be part of the mould, and which in some cases were due to air not only coming in with the metal but also being sucked in through the mould walls. Again, turbulence created in the mould by the air trying to get out could cause a certain amount of dross, and that also became entrapped.

He thought it should have been possible to give practical or general guidance on runner-system ratios—for instance, the cross-sectional area of the downgate to the runner-bar—and the total ingate conditions. Analogy with the behaviour of water could be used, thus if there was a supply pipe of a certain cross-sectional area which was not large enough to supply all the taps seeking to draw from it, air could enter the pipe and upset the flow. Also, he thought it would have been very useful if a table could have been given for the rates of metal flow with various standardized gating systems.

Regarding the aspiration of air, DR. MARTIN said he had tried to explain that provided a runner bush was used and one did not pour straight down the downgate runner no air would be sucked into the casting through the downgate. If the gating system was proportioned properly there would also be no aspiration even through the walls of the mould.

Dealing with gating ratios, he thought the report went fully into this matter. It was stated that the ratios could not be standardized; they depended on the type of gating system employed, the number of junctions and bends and ingates, but for any given system one could calculate area ratios very readily.

Rate of flow, also, he thought, had been well covered in the report. The tables of the rates of flow which had been shown in the form of slides might serve as examples. A great danger with such tables was a tendency to apply them indiscriminately for general work.

MR. R. C. SIDDALL said his firm had had troubles with aspirated air similar to those reported. He recalled reading a paper by American workers whose theory was that if one used parallel-side or cylindrical downgates, as the metal fell down such a runner its velocity increased and therefore air was sucked in. They used Perspex moulds and various liquids and took cinematographic pictures to show the aspiration of the air. They also showed that it could be prevented by tapering the runner—*i.e.*, reducing its area as it went down, so that the area adjusted itself to the velocity of the metal.

MR. VUILLEUMIER (the chairman), in closing the discussion, said he thought Dr. Martin should be thanked sincerely for his presentation of the report, as also should those who had taken part in the discussion.

WRITTEN COMMENT

MR. K. H. COLLINSON wrote that more than one member, while admitting the practical value of this most interesting report, commented that the arithmetic involved in applying the formulæ given in it was a little too difficult for the average foundry foreman. It must have occurred to many, as it did to the writer, that the practical value of all such papers would be greatly enhanced—and reach a wider experimental field—if the formulæ were given in nomogram form. As was well known, a nomogram is a very flexible tool, one that anyone with normal map-reading ability can learn to use quite quickly.

Such a method of presentation would enable and encourage many practical foundrymen to explore the usefulness of the procedures proposed in the report, and result in development work which might be of considerable value to the industry.

Replying to this contribution, DR. MARTIN wrote that because the report covered such a very wide field of a large subject it was not possible to include graphs, curves, tables or nomograms covering all possible uses of the report in the wide variety of foundries existing. Rather, the sub-committee had tried to give the basic data and methods enabling each foundry to compile tables, graphs, etc., most suitable for its particular need.

Speaking as an individual and not as a member of the sub-committee, Dr. Martin expressed some surprise at the antagonism to mathematics in foundries and the opinions, expressed by some speakers, that foundry foremen were semi-illiterate. Being concerned with the design of gating systems, the report was in its details primarily of use to "methods" men, who should be competent to deal with the simple type of arithmetic involved. The foundry foreman, particularly in medium and large shops, was rarely directly concerned with the design of gating systems.

Anti-friction Properties of Spheroidal-graphite Cast Iron

Survey of Recent Russian Research

A considerable amount of work has been undertaken recently on the properties of cast iron containing spheroidal or nodular graphite, some of it in the Soviet Union. Among other contributions in Russian literature are a booklet (No. 55) "High Strength of Iron with Spheroidal Graphite" *Mashgiz*, 1953, and several articles in *Litein Proizvodst* (Foundry Industry) 1951 and onwards. A further important addition has just been made by I. O. Tsypin and co-workers in *Vestnik Mashin*, 1955, **35** (9), 56-61 (September), with special reference to the anti-friction properties of such irons as substitutes for the usual anti-friction metals, including the Russian bronzes, Br.OTsS 5-5-5 and 9-4; also grey iron SChTs2, and wrought titanium-manganese iron.

Materials Tested

The composition of the first-named bronze was: Sn 4.4 per cent., Zn 4.2 per cent., Pb 4.9 per cent., and Cu balance, apart from Sb (0.18 per cent.), Fe (0.16 per cent.), and Al (0.01 per cent), hardness 60 BHN, and of the second: Fe 3.5 per cent., Al 9.0 per cent., balance Cu, and hardness 110 BHN. Tabulated details, together with photomicrographs, are given in the article of six different s.-g. irons (charge mix, additives, and chemical composition) together with another iron having flake graphite, and a TiMn wrought iron. The hardnesses of these two latter was respectively 170 and 158 BHN, and of the s.-g. irons from 207 to 270. In terms of phase structure, the six irons were: completely pearlitic, as-cast; pearlitic plus 8 per cent. ferrite, as-cast; the same plus 5 per cent. ferrite, normalized; the same plus 15 to 20 per cent. ferrite, as-cast; pearlite/ferrite (25 per cent. ferrite), as-cast and similar but with 45 per cent. ferrite, as-cast. In most of these the charge comprised 70 per cent. iron and 20 per cent. steel, plus 10 per cent. ferro-silicon (blast-furnace) in the first four types. The normalized iron was heated to 950 deg. C. for 3 hours, air-cooled, annealed at 600 deg. C. for 2 hours and cooled in the furnace. Melting was carried out in a cupola, and the test castings comprised essentially a sleeve or shell, with a feeder head etc. of 500-mm. dia., overall.

Method

Owing to the complex phenomena and numerous factors involved in determining the suitability of materials assembled in frictional couples, there has hitherto been no generally acceptable or reliable method for measuring anti-friction properties. Field test methods, owing to the length of time needed and high cost, are usually only applied for testing very high-grade material in the laboratory. In the present case, both works' and laboratory tests were made, namely (*a*) on machine of type MI, for measuring the rate of wear and coefficient of friction under various set ups; and (*b*) with apparatus of type LTS-5, closely simulating conditions in the factory, and affording reliable information on which a judgment as to suitability or otherwise in bearings under varied conditions can be formed.

Test-pieces for (*a*) were in the form of partial or segmented bearings contacting with rollers, 40-mm. dia. and 10-mm. wide, the area of contact surface being 2 sq. cm. The roller material was hardened steel (Russian brand 45) of hardness Rockwell C 50 ± 3, and sliding speed 0.42 metres per sec. Tests were run "dry" and the samples had a lengthy "run-in" period before the actual test. Wear was measured by change in weight determined for each 5,000 revs, using an analytical balance of accuracy within 0.0001 gm.

The second apparatus (LTS-5) is for testing under conditions of wet friction. The test-piece in the form of a half-bearing or bush is disposed thereon in a self-adjusting bearing element, where peripheral speeds may be varied from 1.1 to 3.45 metres per sec. During the test, the load on the bearing, the friction moment of the shaft, the temperature of bearing and lubricating oil, and the speed of the shaft all are measured.

"Dry" Results

Results of tests with machine MI are tabulated in the article for three specific pressures: 14, 25, and 50 kg. per sq. cm., showing wear in gm., relative wear (with test-piece No. 1 as unity), and serial order in groups of ten test-pieces—of the roller type. These show clearly the relation between extent of wear of the bearing (bush) and structure of the basic iron containing spheroidal graphite, *e.g.*, wear increased with increasing ferrite content; and on the other hand there was increasing wear resistance with more pearlitic structures. Wear in this case differed little, whether the base structure was as-cast or that obtained after normalizing. Wear on the bearing fell sharply after normalizing of iron with 15-20 per cent. ferrite as-cast.

Compared with the other anti-friction materials tested at the same time, it may be said that the s.-g., iron of mainly pearlitic structure (ferrite not more than 8 per cent.) had greater wear resistance than the two bronzes and the grey and wrought irons. This resistance was lowered if ferrite content exceeded 15 per cent., and then became much less than that of the bronzes and other irons. The highest coefficient of friction, under dry conditions, was shown by pearlitic iron containing flake graphite, and the lowest (among the s.-g. irons) was that of the mainly pearlitic structure. For the bronzes, this coefficient was very much less. With increasing specific pressure the coefficient declined, as a rule. The general conclusion from the summated results—from wear on the two surfaces and friction coefficient—was that the pearlitic s.-g. iron was the best, and was only surpased, as to friction coefficient and roller wear resistance, by the bronzes.

Anti-friction Properties of Spheroidal-graphite Cast Iron

"Wet" Results

The results from tests with instrument LTS-5 are given graphically in the article. These showed that the period of running-in was much longer for the s.-g. irons than for the bronzes (20 to 30 hours against 10). Among the irons, those with spheroidal graphite showed better running-in performance than those having flake graphite or graphite in the form of "temper carbon." They differed little from the bronzes in regard to limiting loads during running-in (120 kg. per sq. cm.). As regards total load capacity, this was maximum with bronze of the type OTsS 5-5-5, followed in descending order by the other bronze, grey iron, and s.-g. irons.

Considering this load capacity as a rather complex property depending on several factors, it cannot be explained merely by structure of the material of the bearing or bush; although, as far as the present tests go, the s.-g. irons proved superior to the wrought iron. Its high value in the case of grey cast iron (SChTs2) showed that lightening the conditions of running-in (self-adjusting bearing or bush) was important for this particular type of iron. Under dry-friction conditions its coefficient of friction was 2 to 2½ times greater than that of bronze.

Experiments under actual works conditions included use in bridge-type overhead cranes, bending rolls, tube-bending machines, hydraulic presses etc., using pearlitic s.-g. irons having 25 to 40 per cent. ferrite. These pretty well confirmed laboratory results, and also emphasized the importance of close attention to clearance in the bearings. Generally, therefore, cast iron with spheroidal graphite can be a valuable substitute for bronzes and other bearing materials.

House Organs

Broomwade News Bulletin, Vol. 18, No. 5. Issued by Broom & Wade, Limited, High Wycombe.

This issue is mainly devoted to the firm's connection with the Engineering, Marine and Welding and Foundry Exhibition, over which Mr. H. Dick Broom presided. It is pointed out that quite a number of this firm's compressors were installed on the stands of the foundry-equipment manufacturers.

Boydell Bulletin, Vol, 1, No. 3. Issued by E. Boydell & Company, Limited, Old Trafford, Manchester, 16.

The general make-up of this house organ is to associate Muir-Hill handling machines with various industries, using simple stories and good illustrations. In this issue the industries cited are coal-mining; china clay; foundry; road making; tunnelling; bagging, and sugar. It makes quite interesting reading.

Ruston Overseas News, No. 19, Vol. 2. Published by Ruston and Hornsby Limited, Lincoln.

The writer knows of no house organ which takes the reader so interestingly to every corner of the earth. Thus articles appear on events and installations in Essex, Melbourne, Gold Coast, Hull and Liverpool, Hong Kong, Alderney, Lochaber, Burma, Toronto, Milan, Peru, Egypt, and Trinidad. No wonder that with such world-wide connections, the Lincoln works have apprentices coming from the ends of the earth. It is good business, because, especially in the near East, reputable agents need experienced engineers to give service after sales.

The Iron Worker—Autumn 1955. Published by the Lynchburg Foundry Company, Lynchburg, Va., USA.

The reviewer always looks forward to receiving this house organ, if for no other reason than to admire the illustrations of the architecture of the old buildings which seem to abound in the state of Virginia. This issue contains some fine examples. It also carries a history of the foundry which dates back to 1896, finishing with the installation of the shell-moulding plant. Finally, the company associates itself by text and illustration with that section of the Foreign Operations Administration—Industrial Technical Co-operation Service—by telling of the reception of numerous visitors from overseas.

New Catalogues

Exhaust Ventilation. Sturtevant Engineering Company, Limited Southern House, Cannon Street, London, E.C.4, in publication No. 3604, cover a wide field of exhaust ventilation ranging from installations in cocktail bars to those in plating plants. It is an interesting brochure, but for the special applications to the foundry industry, there are other publications available, such as No. 6509.

Lighting Fittings.—The Stella Lamp Company Limited, 37/39, Oxford Street, London, W.1, have announced their entry into the fluorescent lighting fittings market in a four-page, two-colour leaflet describing the first of their "Blue Label" range. This range includes ceiling-batten, ceiling-vee, industrial-trough, slotted-light-trough and angle-reflector fittings. All are distinguished by a form of guarantee in the shape of a blue label. Copies of the leaflet are obtainable from the company.

Industrial Diesels. W. H. Dorman & Company, Limited, Stafford, have in catalogue No. 112, given the fullest technical details of their L-Type engines—a series covering 2-, 3-, 4-, 5-, 6- and 8-cylinder units. On a double-page spread, there is illustrated a very large number of interchangeable spart parts. It would have been a real service to users if they could have been numbered to facilitate the requisitioning of replacement components. This 20-page catalogue contains a wealth of technical data of great value to the buyer when selecting the type of unit he needs.

Insulating Refractories. Morgan Refractories, Limited, Battersea Church Road, London, S.W.11, have incorporated in their *Technical Sales Bulletin No. 52,* a number of coloured diagrams which clearly illustrate the advantages to be gained through the use of insulating refractories. The reviewer objects to the Centigrade scale taking second place to Fahrenheit in English technical publications. The Foundry Trades Equipment and Supplies Association have resolved to give Centigrade preference. It should, in justice, be pointed out that in every case both scales are given. The catalogue runs to 38 pages, and is an example of the best type of trade publication. Readers may obtain copies by writing to Battersea.

New Equipment

Angle Grinders

Wolf Electric Tools, Limited, Hanger Lane, London, W.5, have designed and placed on the market two portable electric high-speed, heavy-duty angle grinders AG7 and AG9. For driving them, an entirely new universal-type motor has been introduced which is continuously rated at 1.5 b.h.p. Only thus was it possible to provide the 8,000 r.p.m. and 6,000 r.p.m. for the 7-in. and 9-in. dia. grinding discs respectively, which are the requisite operating speeds for obtaining maximum performance and disc life. Grinding is done with the edge of the disc and both the AG7 and AG9 grinders accommodate discs from $\frac{5}{16}$- to $\frac{1}{8}$-in. thick, but those supplied as standard equipment are $\frac{1}{4}$-in. thick, the others being available as accessories. The $\frac{1}{4}$-in. disc will suit most general requirements in steel, iron and non-ferrous metals. These tools are claimed to be suited to foundry grinding, notching, cutting off risers, runners and gates and the resin-bonded cut-off wheels rapidly cut ferrous metals (including high-alloy steels up to 1-in. dia.), brass, aluminium alloys, and other non-ferrous material. In foundries, the taking of heavy castings to stationary plant for cutting off heads is often obviated.

Infra-red Relays

Recent investigations by research engineers of the British Thomson-Houston Company, Limited, Rugby, have led to a new patented design of electronic relay being introduced using a lead sulphide photo-conductive cell as the sensitive element. The equipment is operated by the invisible infra-red radiation from a hot body (even at black heat) and the built-in relay is capable of controlling an external electric circuit carrying up to 1 amp. at 440 volts a.c. Unlike a photo-electric relay equipment, no separate light source is necessary.

As the equipment was originally developed for use in a steelworks, it was essential that it should be of robust construction and the two equipments now available are suitable for service under the most arduous conditions. One of them, Model IR2, is capable of detecting a body 4 ft. away at 400 deg. C., and a more sensitive model, IR3, will detect a hot plate at 80 deg. C. under ideal conditions at the same distance. Features are the high speed of response and high sensitivity.

The IR2 equipment consists of two units, the electronic circuit components and the relay housed in a small die-cast box, and the detecting head incorporating the sensitive cell. It is essential to keep the cell reasonably cool for efficient operation and to maintain it at a sufficiently low temperature (about 60 deg. C.) it is fitted in a water-cooled housing. By this means, adequate cooling is achieved.

The IR3 equipment is also made up of two units, although the electronic equipment is housed in two die-cast boxes of similar design mounted as one. The water-cooled head differs in that a motor-driven disc is incorporated to interrupt the radiation falling on the cell, thus feeding an a.c. signal to the electronic amplifier.

Crane Rail Lubrication

During long-travel movement, rails and wheels of overhead cranes are subjected to lateral pressures which ultimately lead to wear of rail and wheel flanges. Perhaps even more important is the additional power required, as a result of the friction so caused, especially when moving heavy loads. Centralube, Limited, Great Western Trading Estate, Park Royal Road, London, N.W.10, has introduced the "Centralube" crane rail lubricator, operated according to the De Limon system. It is in fact a special adaptation of the standard "Centralube Multigreasor," Model FZ, driven automatically by the long-travel shaft of the crane. Connected to this multigreaser by metal piping, are two crane-rail applicators, one per rail, which apply lubricant to each side of the rail flange. The base plate of the applicator is mounted on the long-travel frame below the buffer on the centre-line of the rail, as indicated in Fig. 1.

Attached to each base plate are two adjustable penduli each carrying a felt roller pressed against the rail flange by its own weight, assisted by a tension spring. These felt discs roll along the rail flanges, leaving a very thin oil film which is constantly renewed. The applicator felts are mounted on a pivot which fits into the bore of the pendulum. The lubricant is fed to this pivot from the multigreaser through an oil-tight hose. It is introduced into the felt roller through a pivot base and reaches the outer edge through the centrifugal action during movement, thereby applying the lubricant to the rail. The multigreaser is generally mounted near the centre of the crane, its ratchet arm being actuated by a two-part eccentric giving a ratchet angle of approximately 15 deg. Lubricant consumption is very small, usually not more than $\frac{1}{4}$ to $\frac{1}{2}$ oz. per hr. of operation.

Fine Grinding of Samples

A new electrically driven pestle-and-mortar grinder for the fine grinding of samples, announced by

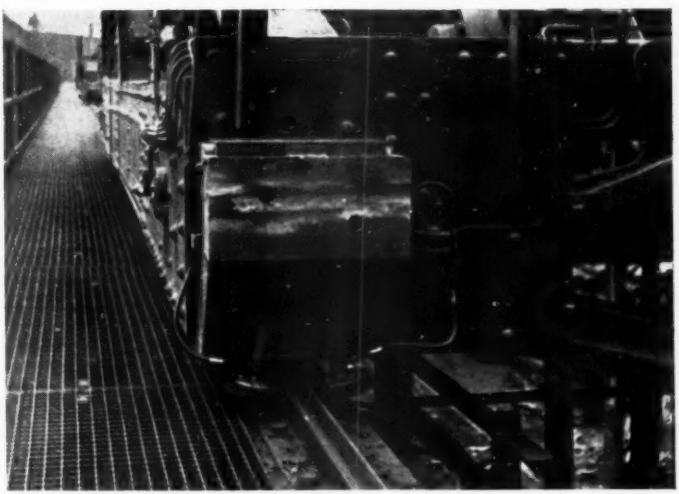


FIG. 1.—*The Centralube Crane Rail Lubricator.*

New Equipment

Herbert Alexander & Company, Limited, Charmouth Street, Leeds, 11, is of particular interest to laboratories.

The feature of the machine is its rapid and efficient action. Driven by a totally enclosed fractional horse-power motor and worm reduction unit, pestle and mortar rotate in opposite directions, the former at 96 r.p.m. and the latter at 32 r.p.m. The mortar is fitted into a hardwood holder which rests freely on the sponge rubber bed of the carrier. The mortar thereby assumes an inclination to the horizontal plane under the pestle, giving even grinding pressure and concentrating the sample under the pestle, the centre line of which is offset to that of the mortar. The pestle is instantly retractable for withdrawal of the ground sample.

In the standard machine the pestle and mortar are of polished agate, but alternative materials are available.

Quartz Infra-red Lamp

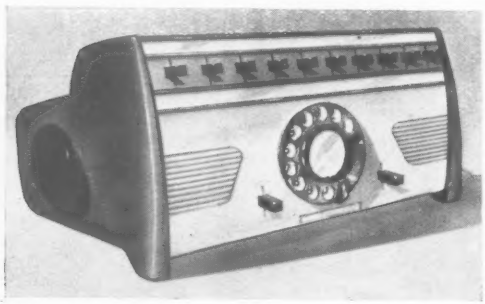
In order to provide higher radiation intensities than are normally obtainable from an ordinary 250 w. industrial infra-red lamp, Philips Electrical Limited, Century House, Shaftesbury Avenue, London, W.C.2, have developed what is claimed to be the first 1,000 w. quartz tubular infra-red lamp in Europe. Because of the thermal strain to which glass is likely to be subjected, the tube is made of quartz; this substance is not only particularly resistant to high temperatures but, because of its low co-efficient of expansion, also lends itself to rapid local cooling. The lamp has a power consumption of 1,000 w. and a diameter of only 10 mm. The length of the filament is approximately 290 mm. Thus, the power consumption per centimetre is in the region of 35 w. The life of the lamp is approximately 5,000 hours when operated on the rated voltage.

Works Communications

Claimed to be the first completely successful loud-to-loud loudspeaking telephone, the Winston "Tellaloud" (Fig. 2) consists of a cabinet housing a loudspeaker, microphone and microphone amplifier, automatic telephone dial, if required, and internal communications switch keys and separate amplifier or power unit. The cabinet sits on the user's table, while the power unit may be placed up to 100 ft. away.

The equipment can be used for internal and external local calls, and for trunk, toll, and other long-distance calls. The instrument adjusts to the required conditions by the movement of one key lever. The maker is Winston Electronics, Limited, Shepperton (Middlesex).

FIG. 2.—*Winston "Tellaloud" Mark II.*



Packless Control Valve

The range of Stabilflo control valves, made by Foxboro-Yoxall, Limited, Lombard Road, Merton, London, S.W.19, has been further extended with the introduction of a pneumatically-operated control valve having a positive leakproof metallic bellows seal built in below the conventional stuffing box. The normal stuffing box is retained and becomes an emergency safety seal. The valve is designed for use on those processes involving liquids which cannot be allowed to escape (even in the minute amounts that might pass the conventional packing gland) because of the danger or loss involved. Field experience has led to the developing of manufacturing techniques which result in a bellows with exceptionally long life, and which continues to function properly after difficult service, including both throttling and open and shut applications.

Floor-sweeping Attachment

Filtavac, Limited, 64a, Kensington Church Street, London, W.8, manufacturers of portable industrial vacuum-cleaning plants, announce the development of an attachment for coupling (in a few seconds) to their model RM 22 machine for large-area floor and gangway sweeping. It is claimed that without interfering with production, dust and dirt are efficiently removed, and an adjustable slide incorporated in the tool allows the removal of the usual factory *débris* without raising any harmful dust. The new attachment, called the "Chevron Floorsweeper," is made in three standard widths of 18, 24, and 30 in. or, for extra-large areas, a 50-in., the latter to suit the Filtavac RM 44 twin.

Loading-rate Indicator

A new feature recently introduced by Saml. Denison & Son, Limited, Hunslet Foundry, Leeds, 10, to their model T42B3 self-indicating Universal testing machine is the No. 36 load-pacing device, the registering portion of which is incorporated in the dial indicator. With certain materials, it is desirable to apply the load on the specimen at a constant and pre-determined rate. The load pacer consists of a disc, operated by a fractional h.p. motor, which rotates at a pre-selected speed. The hydraulic control makes it an easy matter to apply the load at the rate set by this pacer, which has a wide range of speed.

Board Changes

KIRBYS, LIMITED—Dr. Alan Clowes Kirby has been appointed a director.

MASSON SCOTT & COMPANY, LIMITED—Mr. S. R. Hogg has resigned from the board.

J. A. PRESTWICH INDUSTRIES, LIMITED—Mr. W. R. Bishop has accepted an invitation to join the board.

STEPHENSON CLARKE, LIMITED—Mr. Horace Sydney Bennett has been appointed a director of the company.

RIPPINGILLES, LIMITED—Mr. A. Whittaker Richardson has been appointed an additional director of the company.

BRADLEY & COMPANY, LIMITED—Mr. T. Leslie Perry has been appointed chairman in succession to the late Mr. Hermon Bradley.

UNIVERSAL ASBESTOS MANUFACTURING COMPANY, LIMITED—Lt.-Gen. Sir Otto Marling Lund has accepted an invitation to join the board of the company.

MITCHELL, SHACKLETON & COMPANY, LIMITED—Mr. Walter Gribbin has resigned from the board of the company and from the subsidiary, Clarke's Crank & Forge Company, Limited.

News in Brief

ROLLS-ROYCE, LIMITED, are to expand their oil-engine division at Derby.

JOINT STUDY and development of electronic machine-tool control equipment are to be undertaken by the Electric & Musical Industries, Limited, group and the Cincinnati Milling Machine Company, of the United States.

A NEW COMPANY, Plessey Research, Limited, has been formed to control the various research establishments of the group headed by the Plessey Company, Limited, general engineers, radio-instrument makers, etc., of Ilford (Essex).

TWENTY-THREE EMPLOYEES of Sheepbridge Stokes, Limited, Sheepbridge Equipment, Limited, and Sheepbridge Alloy Castings, Limited, have been presented with gold watches on completion of 25 or more years' service with the companies.

THORNCLIFFE WORKS CRICKET CLUB held their annual dinner and prize distribution at the Midland Hotel, Chapeltown, Sheffield, on December 9. Among the chief guests was Mr. Herbert Sutcliffe, the former England and Yorkshire player.

PLANS have been approved by Tynemouth Corporation for alterations to the works of the British Die Casting & Engineering Company, Limited, West Chirton, and the Hayhole lead works, North Shields, of Associated Lead Manufacturers, Limited.

ABOUT 700 EMPLOYEES and friends of Guest & Chrimes, Limited, waterworks fitting manufacturers, attended the annual dance of the firm's social club at Rotherham on December 9. It was a record attendance for the 20 years that the dance has been held.

A FIRE which broke out at the foundry in Midland Road, Wellingborough, Northants, of Joseph Williamson & Company, Limited, caused damage to sleepers in a corrugated-iron building, but prompt action by the firemen prevented other buildings from becoming involved.

AN URGENT NEED for an engineering technical college centrally situated in Edinburgh is mentioned in a report by Mr. James B. Frizell, director of education, to Edinburgh Corporation Education Committee. The need for a new building technical college and college of commerce is also underlined.

MAKERS of diesel engines, motor vehicles, generators, and other engineering products will be among the British companies which are together occupying the 22,000 sq. ft. of covered and outdoor space allocated to British manufacturers at the spring fair to be held in Leipzig from February 26 to March 8, 1956.

SELECTED EMPLOYEES of the Revo Electric Company, Limited, Tipton (Staffs), may, on reaching 65, or earlier if in poor health, enter the "long-service department," where they can choose their own working hours and rest when they want to. Payment for work, which is of a light nature, is on a piece-rate basis.

A REVIEW carried out by British Insulated Callender's Cables, Limited, showed that at the end of October there were 73 employees with 50 or more years' service with the company and its two predecessors and 528 with 40 or more years. At the time of the review, there were about 100 pensioners with over 50 years' service.

LARGER PREMISES have been obtained for Electrical Engineers (ASEE) Exhibition, Limited, the Electrical Engineers Exhibition company, at 6, Museum House, 25, Museum Street, London, W.C.1, where it is dealing with all correspondence and interviews. The registered office and the telephone number (MUSeum 3450) are unchanged.

J. H. FENNER & COMPANY, LIMITED, Hull, held a two-day exhibition for industrialists and engineers, of mechanical power transmission, at their Marfleet works on December 7 and 8. The exhibition included a new application of the taper lock to sprocket and chain drives, and the extension of the range of torque-arm shaft-mounted speed reducers.

THE SPORTS CLUB of W. Jessop & Sons, Limited, steelmakers, Brightside Works, Sheffield, reported a membership of a total equal to 97 per cent. of the firm's employees, at the annual meeting. A new archery section was formed during the year, making 25 active sections. Contribution income from the company and members in the year was £3,630.

A WARNING that the company could not afford to relax its efforts to build up apprentice numbers in the ironworking trades was given by Capt. J. E. Sissmore, personnel manager of Vickers-Armstrongs (Shipbuilders), Limited, at the company's apprentices' prize-giving. He reported an increase in the total number of apprentices, but the increase as far as the ironworking trades were concerned was not good enough.

IN ORDER to make its workers more aware of the importance of safety in industry, the Steel, Peech & Tozer branch of the United Steel Companies, Limited, has appointed 300 of its men as "safety stewards" in addition to their ordinary work. Their job is to keep impressing on their colleagues the importance of safety at work and of first-aid measures, by emphasizing, for example, the need for wearing safety boots and protective clothing.

SIR DAVID ECCLES, Minister of Education, visited on December 9 the Rugby works of the British Thomson-Houston Company, Limited, to view the facilities provided for the training and welfare of apprentices. Sir David inspected the company's main training drawing office, the lecture theatre, where a display of work produced in the apprentice training workshop was on view, and an exhibition showing the methods used in training apprentices in drawing office work.

UNDER the pensions scheme of Thos. W. Ward, Limited, Sheffield, widows of employees who die before retirement are now to receive pensions from £52 to £78 a year, according to the husband's years of service. A minimum of 20 years' service by the husband is required before the widow qualifies for the pension. The pensions scheme was started by the company in 1949, when it made a payment of £200,000 to cover back service of employees. The funds now total nearly £900,000.

Mr. J. WILSON, principal of the Birmingham College of Technology, has stated that it is almost certain that applications will be submitted on its behalf for approval for the Diploma of Technology of the new "sandwich" courses in mechanical and production engineering, electrical engineering, metallurgy, applied physics and applied chemistry. These courses were designed to reach a high standard in technology with a sound knowledge of the basic sciences and some liberal studies.

THE WHOLE of the issued share capital of W. E. Bray & Company, Limited, manufacturers of loaders and earth-moving equipment, of Feltham (Middx), has been acquired by Sheepbridge Engineering, Limited,

News in Brief

Chesterfield. The latter company recently acquired as a subsidiary the Harold Andrews Grinding Company, Limited, manufacturers of cylinder liners and of "Flocast" continuously-cast iron bar, of Halesowen (Worcs), whose name in consequence has been changed to Harold Andrews Sheepbridge, Limited.

EDGAR ALLEN & COMPANY, LIMITED, Imperial Steel Works, Sheffield, announce that they have just signed a three-quarter-million-pound contract with the Seven-Year-Plan Organization of Iran for the supply of cement-making machinery and equipment for the proposed portland cement factory at Doroud, Iran. The plant will produce daily 600 tons of portland cement. It is understood that this is the first instance since the war of an order for a plant of this description being secured in the face of international competition.

A PROJECT is nearing completion at the Tyssedal works of the Norwegian company, Det Norske Nitridaktieselskap, to raise its annual aluminium output capacity by 5,000 tons. Two more schemes planned by A/S Ardal og Sunndal Verk, which is State-owned, aim at an increased anual output capacity of 36,000 tons above its present 24,000 tons. A fourth project involves a new plant at Mosjoen of 20,000 tons capacity to be built by Elektrokemisk A/S. These increases would bring Norway's annual capacity to 170,000 tons.

A NEW PENSION and life-assurance scheme to benefit hourly-paid employees has been introduced by the English Electric Company, Limited. It comes into effect from January 1, and will affect all hourly-rated employees, men and women, who have completed 25 years' service or more by the time they reach 65. The company will now pay £300 to the estate of all male employees who dies over the age of 25, after having completed four years' service. The insurance will be increased to £500 after 25 years' service. All benefits will be provided at the cost of the company.

MR. C. H. T. WILLIAMS, managing director of the Park Gate Iron & Steel Company, Limited, presented 60 outside awards to students of the Rotherham Technical College at their prize distribution. Mr. G. E. Cooke, principal of the college, said that plans announced last year for an extension of the college would have to be enlarged if the number of students continued to increase at the same rate during the next three or four years. The increase of students over the last five years, he said, was 700, and there had been an increase of 500 during the last year. About 5,000 students were attending at present.

Mr. RONALD STEEL, chairman of Pickford, Holland & Company, Limited, refractory goods manufacturers, Sheffield, has announced that because of the increasing cost of coal, and to improve the quality of their basic bricks, the directors have decided to put up at Totley and at Crook continuous oil-fired tunnel kilns to take the place of the small coal-fired round kilns. It is hoped that the Totley plant will be working before the end of March and the one at Crook three months later. The installations will have cost £150,000 but financial help for 40 per cent. of this sum has been arranged through the Ministry of Fuel and Power in the form of loans for repayment over ten years.

ADDRESSING the Birmingham Junior Chamber of Commerce on December 6, Dr. Robert Aitken, vice-chancellor of Birmingham University, expressed concern at the effect the high salaries offered to graduates by industry are having on the supply of science lecturers and professors for the universities. The general quality of the men available to the universities was being lowered, he said. Dr. Aitken referred to Sir Winston Churchill's warning that Russia is leading Britain in technological training. He said that this was also true of America and Germany. The great American industrial success was due to the far higher proportion of young men in the United States who were trained to a higher level in science and technology.

A MEMBER of the staff of the Export Credit Guarantee Department, Mr. R. S. Kinsey, left on December 11, for a six months' tour of Middle East countries, including Iran, Iraq, Persian Gulf States, Saudi Arabia, Syria, Lebanon, Jordan, Israel, Egypt, Sudan and Ethiopia. Representatives of UK firms visiting any of these markets over this period can assist the enquiry by making contact with Mr. Kinsey during their visit; mail addressed to him at the British Embassy, Baghdad (from which he is to operate) will be forwarded. Introductions to local representatives, suggestions for modifications in cover, or notes of problems encountered, from other firms with experience in these markets, will also be appreciated, and these may be sent to Mr. Kinsey direct or to ECGD for forwarding.

FURTHER ORDERS have reached Clyde shipyards. Scotts Shipbuilding & Engineering Company, Limited, Greenock, have secured one for two 12,200-ton oil tankers which brings the total number of orders received by Clyde yards since the beginning of the month to twelve ships, totalling over 40,000 gross tons. Latest contract to be placed by the Burma Government goes to Yarrow & Company, Limited, Glasgow, and comprises five motor ships of 400 tons displacement. Diesel engines for these vessels will be supplied by the National Gas & Oil Engine Company, Limited. The same builders have been commissioned to build a steamer of 325 tons displacement by the Nigerian Government. Yarrow's specialize in the construction of shallow-draft vessels; many of their ships are sent out in sections to foreign countries and there reassembled.

AFTER NINE MONTHS of inquiry and experiment the Scottish Council (Development & Industry) are satisfied of the need for a permanent technical-liaison service to assist the small and medium-size firms in the engineering industry in Scotland. In the first instance, the Council received a grant of £3,000 from the Department of Scientific and Industrial Research, under the Conditional Aid scheme, to undertake a survey of existing means of disseminating scientific information and set up a technical-liaison service on an experimental basis. Already a team of three experienced engineers has visited 120 firms and dealt with inquiries ranging in subject from points of design to costing systems. The question, however, of how a permanent service is to be financed and operated remains to be settled, and it is apparent that it cannot be answered without reference to DSIR, the Scottish Office, and the great body of industry in Scotland.

Obituary

Mr. ARTHUR HUDSON, a director of Arthur Hudson Forge & Engineering Company, Limited, Brighouse (Yorks), has died at the age of 60.

Mr. ANDREW HARPUR MICHELL, chairman of Holman, Michell & Company, Limited, lead and brass manufacturers, of St. Helens (Lancs), died on December 11 at the age of 63.

Mr. G. C. TROWBRIDGE, who has died at the age of 67, was managing director of Wickman, Limited, machine-tool makers, of Coventry, from 1947 until his retirement last year.

Personal

TECALEMIT, LIMITED, Plymouth and Brentford, announce the appointment of Mr. T. R. HARDMAN to the position of general manager.

MR. L. HOLLAND and MR. F. G. ROWLAND have been appointed directors of Switchgear & Cowans, Limited. Mr. DOUGLAS HEWITT is made an additional director.

MR. LAWRENCE W. ROBSON has been appointed chairman of the Parsons Engineering Company, Limited. He succeeds MAJOR R. C. W. NEALE who has resigned as chairman.

DR. H. H. BURTON, director of metallurgy research at the English Steel Corporation, Limited, Sheffield, has been nominated for election as president of the Iron and Steel Institute at next year's meeting.

THE APPOINTMENT is announced of Mr. J. E. BYWATER as manager of the Ford Motor Company's Birmingham research centre. Mr. Bywater, who is 34, has been with the company for 16 years. He succeeds Mr. G. H. TUNNA, who has taken up an appointment at Dagenham.

Mr. FRANK CHAMBERS, who retired on September 23 after 51 years' service with Newton Chambers & Company, Limited, has revisited the Thorncliffe works to receive a presentation on behalf of the shop stewards. Mr. Chambers is a direct descendant of Thomas Chambers, co-founder of the company in 1793.

Mr. T. G. W. WATSON, manager of R. & H. Green & Silley Weir, Limited, has been appointed chairman of the River Thames Shiprepairers Association; Mr. R. DIXON, manager of J. Russell & Company, has been appointed vice-chairman. The Association has given up the old name of the River Thames Dry Dock Proprietors and Shiprepairers Association in favour of the new title.

DR. T. P. HUGHES, M.A., has been appointed director of the Tube Investments Research Laboratories at Hinxton Hall, Cambridge. Dr. Hughes was head of the chemistry department and subsequently chief superintendent of the Rocket Propulsion Department of the Royal Aircraft Establishment before joining Tube Investments, Limited. DR. F. B. BOWDEN, F.R.S., is chief research consultant to the company.

DISTINGTON ENGINEERING COMPANY, LIMITED, a branch of the United Steel Companies, Limited, announce that Mr. T. S. KILPATRICK will relinquish his duties as commercial manager on his appointment as deputy general manager of the Workington Iron and Steel Company on January 1. He will remain a director of the Distington Company. On the same date, Mr. A. E. BELL, sales manager (engineering), is appointed general sales manager and Mr. T. WINTRUP, contracts manager, will become sales manager (engineering).

SHEEPBRIDGE ALLOY CASTINGS, LIMITED, a subsidiary of Sheepbridge Engineering, Limited, announces that Mr. G. BREWER has been appointed cast-iron and bronze foundry manager. For some years he has been employed in various technical capacities with Sintered Products, Limited, another member of the group. Mr. D. BERRIDGE has taken up his appointment as sales manager of the company after eight years in a similar capacity with Catton & Company, Limited, steelfounders, of Leeds. Mr. E. G. SCRANNAGE, previously with Ford Engines Research at Birmingham, has been appointed methods engineer of Sheepbridge Alloy Castings, while Mr. S. MARTON, metallurgist of Sintered Products, has been appointed to a new research post in charge of the development of a process for the continuous casting of bronze tubes.

Law Cases

Award Against Foundry Company

At Staffordshire Assizes, Charles Upton (47), of Exeter Place, Pleck, Walsall, was awarded damages totalling £2,068 15s. 10d. against his former employers, Bradley & Foster, Limited, pig-iron makers, etc., of Darlaston. It was stated that while working in the nut shop at the company's works on May 22, 1952, Upton spilled molten metal over his right foot. As a result of his injuries he had to have nine operations, during which all the toes on that foot were amputated.

In his summing-up, Mr. Justice Cassels said Upton had been made a very lame man, who might be able to walk a short distance with a stick.

Damages to be Paid by Steel Company

Total damages of £1,298 and costs were awarded by Mr. Commissioner Wrangham at the West Riding Assizes at Leeds to Ralph Barraclough (30), fitter, of Beaconsfield Road, Broom Lane, Rotherham, for injuries sustained when a 2-ton bedplate fell on his left arm when he was working for the Park Gate Iron & Steel Company, Limited, at Rotherham, in 1952. The commissioner said that Barraclough was an enterprising and intelligent man who was likely to overcome his disability.

Mr. P. Stanley Price applied for a stay of execution, which was granted.

Gregson *v.* Hick Hargreaves Appeal Decision

The decision in the case of Gregson *v.* Hick Hargreaves & Company, Limited, referred to in the article "Silica Dust, Foundries and the Factories' Act (1937)," published in the JOURNAL of October 27, has now been reversed by the Court of Appeal. This Court has taken the view that by not providing masks for moulders likely to come into contact with the dust the company had failed to take "all practicable measures," and it was not a defence to employers who failed in respect of visible dust to contend that invisible dust, of which they had no knowledge, caused the trouble.

Joining Fuel Advisory Council

A director of the Manganese Bronze & Brass Company, Limited, Lt.-Col. Samuel James Manson Auld, has been appointed a member of the Ministry of Fuel and Power Scientific Advisory Council. After studying at London and German universities he lectured in agricultural chemistry and then saw distinguished service in the first world war. From 1919 to 1928 he was with the Anglo-Persian Oil Company and joined the Vacuum Oil Company, Limited, in 1930. He is a past-president of the Institute of Petroleum and of the Oil Industries Club.

Col. Auld, who is 71, is by no means a newcomer to the task of advising the Government. Among his wartime commitments was the chairmanship of Enemy Oils and Fuels Committee and he also served as technical adviser to the Petroleum Board, Petroleum (Warfare) Department. From 1939 to 1946 he was chairman of the Lubricating Oil Pool Technical Committee.

AUTOMATIC TELEPHONE & ELECTRIC COMPANY, LIMITED—Following the resignation of Air Vice-Marshal O. G. Lywood from the board, Sir Rex Hodges has been appointed to fill the vacancy.

Raw Material Markets

Iron and Steel

The heaviest demand from the foundries for supplies of pig-iron continues to come from the engineering and speciality foundries, and is chiefly for the low- and medium-phosphorus irons. It is expected that production from the large furnace recently blown in at Dagenham will be on an increasing scale, but even when full capacity is obtained from that source it is doubtful if all demands can be met. Low-phosphorus iron was raised by 16s. a ton on Monday. Common irons are unchanged in price, but hematite is 17s. 6d. dearer and Scotch foundry iron is up 7s. 6d. Higher freights on foreign ore are mainly responsible.

The engineering and speciality foundries continue to be very busy, as the motor, tractor, and allied trades, as well as electrical and power-plant equipment makers, machine-tool manufacturers, and many other trades, have large requirements of castings. The difficulties which have faced these foundries for some time in the supply of the low- and medium-phosphorus irons are unlikely to be remedied in the near future, as there are no signs of additional sources of production. Expansion of outputs of pig-iron has been confined mainly to basic steelmaking iron and the furnaces which have recently been brought into commission and new ones which are scheduled to come into production later will in the main be burdened to supply the steelworks. It is understood, however, that the overall supply of basic pig-iron is satisfactory at present, the main concern of the steelworks being the supply of scrap.

While there has been some improvement in deliveries of hematite pig-iron, the tonnages coming forward barely meet demands, particularly in the high-silicon ranges. The refined-iron makers are also busy.

Production of high-phosphorus foundry pig-iron is still on a good scale and available tonnages are in excess of the quantities which are at present being specified by the consumers of this grade. The light foundries are still short of work, and although the jobbing and many of the engineering foundries which use this grade of pig-iron are taking up fairly good tonnages, some producers are finding it difficult to dispose promptly of their outputs, with the result that they have been able to send some consignments overseas. The credit squeeze and increased purchase tax on such articles as refrigerators, cookers, and other domestic equipment continue to restrict demands for castings from the light foundries catering for these trades.

There is a brisk demand for heavy cast-iron and machinery scrap and new arisings are not large enough to replace usage. The supply of light and medium scrap is on a good scale.

Foundry coke is coming forward in accordance with the allocated tonnages, but it is difficult to obtain any increase on present deliveries, as most of the coke ovens are heavily committed for their outputs, particularly the Welsh ovens.

Non-ferrous Metals

With the end of the year in sight non-ferrous metals are buoyant, emphasizing the continuing boom in the United States and the high level of industrial activity in other parts of the western world. Copper is a strong market on both sides of the Atlantic, with the price for cash metal topping £400 per ton to reach new records. Quotations have been lifted by the situation in Chile, where strike threats have been put into effect at all the plants. Meanwhile, copper stocks are already low both here and in the States and demand shows no sign of easing. Nor can the US industry expect much relief from the stockpiling authorities beyond some diversion of supplies to industry.

The market for tin is still exceptionally strong, due largely to American buying. Political considerations continue to play their part in stimulating demand. The situation in the Middle East is not improving and the political undercurrent in the Far East remains a potential danger. Otherwise, the outlook for tin is bright. Consumption of tinplate in 1956 is expected to be at record levels and stocks are very low on both sides of the Atlantic. However, if US stockpiling ceases next year, as is thought likely in some circles, and there is no international tin agreement to ensure the formation of a buffer stock, the tin price may well come down sharply. At present Indonesia's ratification is necessary for the agreement to become effective and she is not considering the question until next spring.

Lead has been relatively quiet, but demand is steady and the high price is maintained. Talk is still persisting that the price will be raised to 16 cents a pound in the US. With the London price at its present level, it is difficult to believe that the price will not go higher if foreign producers are to maintain any further interest in the transatlantic market.

Zinc holds its strong market in London and New York. Demand is satisfactory for "Prime Western" and strong for special high-grade metal. The London price is firm, although in the States trading is still being carried on at 13 cents a pound, East St. Louis, for "Prime Western." The price, however, is being talked higher in the near future and there is a certain speculative element in the demand.

Official metal prices were as follow:—

COPPER, Standard—*Cash:* December 14, £400 to £401; December 15, £404 to £405; December 16, £395 to £396; December 19, £402 to £403.

Three Months: December 14, £393 to £394; December 15, £396 to £396 10s.; December 16, £388 to £389; December 19, £396 to £396 10s.

TIN, Standard—*Cash:* December 14, £840 to £841; December 15, £832 10s. to £835; December 16, £834 to £837 10s.; December 19, £834 to £835.

Three Months: December 14, £822 10s. to £823 10s.; December 15, £815 to £816; December 16, £819 to £820; December 19, £815 to £816.

LEAD—*First half December:* December 14, £112 15s. to £113; December 15, £112 15s. to £113. *Second half December:* December 16, £112 15s. to £113; December 19, £112 15s. to £113.

First half March: December 14, £112 to £112 5s.; December 15, £112 5s. to £112 10s. *Second half March:* December 16, £112 5s. to £112 10s.; December 19, £112 10s. to £112 15s.

ZINC—*First half December:* December 14, £97 10s. to £98; December 15, £97 15s. to £98. *Second half December:* December 16, £97 10s. to £98 10s.; December 19, £98 to £98 5s.

First half March: December 14, £95 to £95 5s.; December 15, £95 5s. to £95 10s. *Second half March:* December 16, £95 5s. to £95 10s.; December 19, £95 10s. to £95 15s.

Recent Wills

BOWDEN, JOSHUA, of J. Bowden & Son, metal merchants, of Manchester £9,915

GREEN, W. A., formerly representative in the southern Midlands for Hadfields, Limited £14,896

CRAMOND, J. C., principal of Cramond & Company, Limited, iron and steel merchants, engineers, and colliery furnishers, of Dundee £33,871

JOSEPH, G. P., a director of Murex, Limited, manufacturers of carbon-free metals, and alloys, etc., of Rainham (Essex), and of Murex Welding Processes, Limited, Waltham Cross (Herts) ... £129,306

Pig-iron and Steel Production

Statistical Summary of September Returns

The following particulars of pig-iron and steel produced in Great Britain are from statistics issued by the British Iron and Steel Federation. Table I summarizes activities during the past six months. Table II gives production of steel ingots and castings in September, and Table III, weekly average production of finished steel. Table IV gives the production of pig-iron and ferro-alloys in September, 1955, and furnaces in blast. (All figures weekly averages in thousands of tons.)

TABLE I.—*Iron and Steel Price Index and General Summary of Pig-iron and Steel Production.*

Period.	Price Index. 1938 = 100. I. & S.	Coal.	All comdts.	Iron-ore output.	Imptd. ore used.	Coke to blast-furnaces.	Pig-iron, ferro-alloys prod.	Scrap used in steel prod.	Steel (incl. alloy). Imports.[1]	Prod. ingots, castings.	Delivrs. finished steel.	Stocks.[2]
1953	260	350	323	304	207	237	215	188	17	339	262	962
1954	263	364	325	299	234	238	229	198	7	356	277	831
1955—April ..	269	374	329	310	234	242	238	224	29	393	311	844
May ..	269	366	328	313	245	242	242	228	26	402	325	859
June[3]	269	368	331	263	223	221	217	206	31	364	286	866
July ..	272	423	338	294	230	241	231	170	29	308	254	999
Aug.[3]	283	423	338	307	244	245	236	189	36	345	257	1,200
Sept. ..	283	424	338	333	247	251	246	224	37	398	—	1,222

TABLE II.—*Weekly Average Production of Steel Ingots and Castings in September*, 1955.

District.	Open-hearth. Acid.	Open-hearth. Basic.	Bessemer.	Electric.	All other.	Total. Ingots.	Total. Castings.	Total ingots and castings.
Derby, Leics., Notts., Northants and Essex ..	—	3.6	14.0 (basic)	2.1	0.2	18.8	1.1	19.9
Lancs. (excl. N.W. Coast), Denbigh, Flints. and Cheshire	1.3	33.5	—	2.3	0.4	36.1	1.4	37.5
Yorkshire (excl. N.E. Coast and Sheffield) ..								
Lincolnshire	—	38.5	—	—	0.1	38.4	0.2	38.6
North-East Coast	1.2	73.7	—	1.5	0.5	74.8	2.1	76.9
Scotland	3.2	42.3	—	2.2	0.4	46.1	2.0	48.1
Staffs., Shrops., Worcs. and Warwick	—	19.5	—	1.3	0.8	19.5	2.1	21.6
South Wales and Monmouthshire	4.9	79.5	6.3 (basic)	1.3	0.2	91.4	0.8	92.2
Sheffield (incl. small quantity in Manchester) ..	10.3	33.3	—	11.7	0.5	53.8	2.0	55.8
North-West Coast	—	1.7	4.8 (acid)	0.6	0.1	7.1	0.1	7.2
Total	20.9	325.6	25.1	23.0	3.2	386.0	11.8	397.8
August, 1955[3]	15.9	284.7	24.3	17.6	2.6	335.7	9.4	345.1
September, 1954[3]	21.7	303.2	24.6	19.4	3.4	361.4	10.9	372.3

TABLE III.—*Production of New Non-alloy and Alloy Finished Steel.*

Product.	1953.	1954.	1954. Aug.	1955. July.	1955. Aug.*
Non-alloy steel:					
Ingots, blooms, billets and slabs[6]	4.7	5.1	3.8	3.8	3.9
Heavy rails ..	8.7	9.6	6.9	8.9	6.1
Sleepers, fishplates and soleplates ..	2.2	1.9	1.1	1.9	2.3
Plates, ¼ in. thick and over ..	46.5	47.0	42.9	36.5	37.3
Other heavy prod.	43.9	45.8	36.2	35.0	40.4
Ferro-concrete rods, etc.	5.1	5.9	6.2	6.4	6.2
Wire rods (incl. coiled rods, etc.	15.6	19.7	19.8	13.9	19.4
Light rolled prod.	44.2	41.2	32.5	37.0	38.0
Bright steel bars	6.7	6.3	4.9	6.9	6.3
Hot-rolled strip ..	18.8	21.7	17.2	20.0	18.4
Cold-rolled strip ..	5.2	7.0	5.8	7.1	6.7
Sheets, incl. coated	34.1	38.8	29.8	37.0	36.8
Tinplate, terne-plate and black-plate	14.9	16.8	12.6	15.2	15.1
Steel tubes and pipes	20.1	20.0	15.9	22.3	18.3
Tube and pipe fittings (excl. flanges) ..	0.3	0.4	0.3	0.4	0.3
Tyres, wheels and axles	4.4	4.7	3.9	5.2	3.9
Forgings (excl. drop forgings) ..	3.1	2.6	2.1	2.1	2.1
Steel castings ..	4.0	4.0	3.8	3.2	3.8
Tool and magnet steel	0.3	0.2	0.2	0.3	0.2
Total	282.8	298.7	245.9	263.1	265.5
Alloy steel	13.7	13.2	10.7	12.8	11.8
Total deliveries from U.K. prod.[4] ..	296.5	311.9	256.6	257.9	277.3
Add: Imported finished steel ..	6.8	5.0	5.2	18.4	18.8
Deduct: Intra-industry conversion[6] ..	303.3 42.6	316.9 41.5	261.8 33.7	294.3 41.1	296.1 40.3
Total net deliveries of new material ..	260.7	275.4	228.1	253.2	255.8

TABLE IV.—*Production of Pig-iron and Ferro-alloys during September*, 1955.

District.	Furnaces in Blast.	Hematite.	Basic.	Foundry.	Forge.	Ferro-alloys.	Total.
Derby, Leics., Notts., Northants and Essex	25	—	19.2	23.3	1.0	—	43.5
Lancs. (excl. N.W. Coast), Denbigh, Flints. and Cheshire Yorkshire (excl. N.E. Coast and Sheffield) ..	6	—	14.4	—	—	1.6	16.0
Lincolnshire ..	10	—	37.6	—	—	—	37.6
North-East Coast	22	4.7	50.1	—	—	1.5	56.3
Scotland	9	0.7	15.7	1.7	—	—	18.1
Staffs., Shrops., Worcs., and Warwick ..	7	—	9.9	1.4	—	—	11.3
S. Wales and Monmouthshire	10	4.8	35.7	—	—	—	40.5
Sheffield ..	2	—	3.4	—	—	—	3.4
North-West Coast	8	19.3	—	0.2	—	—	19.5
Total ..	99	29.5	186.0	26.6	1.0	3.1	246.2
August, 1955* ..	98	27.3	175.5	28.2	1.4	3.8	236.2[7]
September, 1954[3]	93	27.0	165.9	26.0	0.7	3.2	222.9

[1] Weekly average of calendar month.

[2] Stocks mainly ingots and semi-finished at the end of the years and months shown.

[3] Five weeks, all tables.

[4] Other than for conversion into any other form of finished steel listed.

[5] Includes finished steel produced in the U.K. from imported ingots and semi-finished steel.

[6] Material for conversion into other products also listed in this table.

[7] Including 100 tons direct castings.

Current Prices of Iron, Steel, and Non-ferrous Metals

(Delivered unless otherwise stated)

December 19, 1955

PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £17 1s. 0d.; Birmingham, £16 13s. 3d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £19 8s. 0d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £19 8s. 3d.

Scotch Iron.—No. 3 foundry, £19 13s. 0d., d/d Grangemouth.

†**Cylinder and Refined Irons.**—North Zone, £21 3s. 0d.; South Zone, £21 5s. 0d.

†**Refined Malleable.**—P, 0.10 per cent. max.—North Zone, £22 0s. 0d.; South Zone, £22 3s. 0d.

Hematite.—Si up to 2 per cent., S. & P. over 0.03 to 0.05 per cent.:—N.-E. of England (local iron), £20 2s. 6d. Scotland (Scotch iron), Zone S. 1, £20 9s. 0d. Sheffield, £21 9s. 6d.; Birmingham, £21 17s. 0d.; Wales (Welsh iron), £20 9s. 0d.

Basic Pig-iron.—£17 8s. 0d. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered)

Ferro-silicon (6-ton lots and over).—45 per cent. Si, nominal, scale 14s. per unit; 35 per cent. Si, nominal, scale 39s. per unit.

Ferro-vanadium.—50/60 per cent., 23s. 8d. to 25s. 0d. per lb. of V.

Ferro-molybdenum.—65/75 per cent., carbon-free, 11s. 0d. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £230 0s. 0d.; 38/40 per cent., £279 0s. 0d.

Ferro-tungsten.—80/85 per cent., 18s. 3d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 21s. 3d. per lb. of W.

Ferro-chrome (6-10 ton lots).—4/6 per cent. C, £88 10s. 0d. to £95 0s. 0d., basis 60 per cent. Cr, scale 28s. 0d. to 32s. 0d. per unit; over 6 per cent. C, £87 10s. 0d. to £93 0s. 0d., basis 60 per cent. Cr, scale 28s. 0d. to 32s. 0d. per unit; 2 per cent. C* 2s. 1d. per lb. Cr.; 1 per cent. C,* 2s. 1½d. per lb. Cr; 0.15 per cent. C,* 2s. 2½d. per lb. Cr; 0.10 per cent. C,* 2s. 2¾d. per lb. Cr; 0.06 per cent. C,* 2s. 3d. per lb. Cr.

Metallic Chromium.—98/99 per cent., 7s. 0d. to 7s. 6d. per lb.

Metallic Manganese.—93/95 per cent., carbon-free, £249 0s. 0d.; 96/98 per cent., £269 0s. 0d.

Ferro-columbium.—60/75 per cent., Nb + Ta, 28s. per lb., Nb. + Ta.

Ferro-manganese (home).—78 per cent., £54 10s. 0d.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £26 10s. 0d.; tested, 0.08 to 0.25 per cent. C, £27 10s. 0d.; hard (0.41 to 0.60 per cent. C), £29 5s. 6d.; silico-manganese, £37 12s. 6d.; free-cutting, £31 0s. 6d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £34 12s. 0d., silico-manganese, £36 12s. 6d.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £32 11s. 0d.; basic, hard, over 0.41 up to 0.60 per cent., C, £33 13s. 6d.; acid, up to 0.25 per cent. C, £36 12s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £33 1s. 6d.; boiler plates (N.-E. Coast), £35 11s. 6d.; floor plates (N.-E. Coast), £34 10s. 6d.; sectional material, N.-E. Coast, £30 19s. 6d.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested, £34 7s. 0d.; flats, 5 in. wide and under, £34 7s. 0d.; hoop and strip, £35 1s. 6d.; uncoated strip mill coils, hot rolled, under 3mm. to 12g., £36 5s. 0d.; black sheets (hand mill), 17/20 g., £46 13s. 6d.; galvanized corrugated sheets, 24 g., £58 11s. 0d.

Alloy Steel Bars.—1 in. dia. and up: Nickel, £58 0s. 3d.; nickel-chrome, £81 10s. 0d.; nickel-chrome-molybdenum, £92 7s. 6d.

NON-FERROUS METALS

Copper.—Cash, £402 0s. 0d. to £403 0s. 0d.; three months, £396 0s. 0d. to £396 10s. 0d.; settlement, £403 0s. 0d.

Copper Tubes, etc.—Solid-drawn tubes, 3s. 9½d. per lb.; rods, 443s. 9d. per cwt. basis; 20 s.w.g., 470s. 6d. per cwt.

Tin.—Cash, £834 0s. 0d. to £835 0s. 0d.; three months £815 0s. 0d. to £816 0s. 0d.; settlement, £835 0s. 0d.

Lead (Refined Pig).—Second half December, £112 15s. 0d. to £113 0s. 0d.; second half March, £112 10s. 0d. to £112 15s. 0d.

Zinc.—Second half December, £98 0s. 0d. to £98 5s 0d.; second half March, £95 10s. 0d. to £95 15s. 0d.

Zinc Sheets, etc.—Sheets, 15 g. and thicker, all English destinations, £129 15s. 0d.; rolled zinc (boiler plates), all English destinations, £127 10s. 0d.; zinc oxide (Red Seal), d/d buyers' premises, £109 0s. 0d.

Brass Tubes, etc.—Solid-drawn tubes, 2s. 11⅞d. per lb.; rods, drawn, 3s. 9d.; sheets to 10 w.g., 373s. 0d. per cwt.; wire, 3s. 6⅝d.; rolled metal, 358s. 9d. per cwt.

Brass (Brazing).—BS1400, B3 (65/35), £235; B6 (85/15), —; BS249, —

Brass (High Tensile).—BS1400, HTB1 (30 tons), £293; HTB2 (38 tons), £300; HTB3 (48 tons), —.

Gunmetal.—BS1400, LG2 (85/5/5/5), £333; LG3 (86/7/5/2), £345; G1 (88/10/2/½). £420; (88/10/2/1), £406.

Phosphor Bronze.—BS1400, PB1 (AID released), £428 per ton.

Phosphor Bronze Strip, etc.—Strip, 523s. 9d. per cwt.; sheets to 10 w.g., 547s. 3d. per cwt.; wire, 5s. 4½d. per lb.; rods, 4s. 8½d.; tubes, 4s. 6¾d.; chill cast bars: solids 4s. 8½d., cored 4s. 9½d. (CHARLES CLIFFORD, LIMITED).

Nickel Silver, etc.—Rolled metal, 3 in. to 9 in. wide × 0.056, 4s. 6d. per lb.; round wire, 10g. in coils (10 per cent.), 4s. 10½d.; special quality turning rod, 10 per cent., ½ in. dia., in straight lengths, 4s. 9½d. All prices are net.

Other Metals.—Magnesium, ingots, 2s. 4d. per lb. Antimony, English, 99 per cent., £210 0s. 0d. Quicksilver, ex-warehouse, £89 0s. 0d. to £89 10s. 0d. Nickel, £519 0s. 0d. Aluminium ingots, £171 0s. 0d.; aluminium bronze (BS1400), AB1, £374; AB2, £386. Solder, brazing, BS1845, 3s. 1d. lb.; granulated, 3s. 4½d. lb.

* Average 68-70 per cent.
† Prices under consideration.

Publications Received

FBI Register of British Manufacturers, 1956. Published for the Federation of British Industries by Kelly's Directories Limited, Dorset House, Stamford Street, London, S.E.1.; price 42s. post free.

This edition follows the same pattern as the earlier editions, which have proved so successful. The commendations given in the past still hold good, for the book is very intelligently compiled and excellently presented.

Operator's Safety Code; issued by the Industrial Truck Manufacturers' Association, 94/98, Petty France, S.W.1. Price 1s. post free.

As this booklet is meant to be used by truck drivers, very sensibly it has been bound in spongeable stiff backs. The rules are clearly expressed, and are illustrated by sketches designed to appeal to the type of individual performing this task. It is in every way an excellent publication, and its use should go far in the prevention of accidents.

Iron and Steel Trades in 1955—Special Review; issued by Wm. Jacks & Company, Limited, Winchester House, Old Broad Street, London, E.C.2.

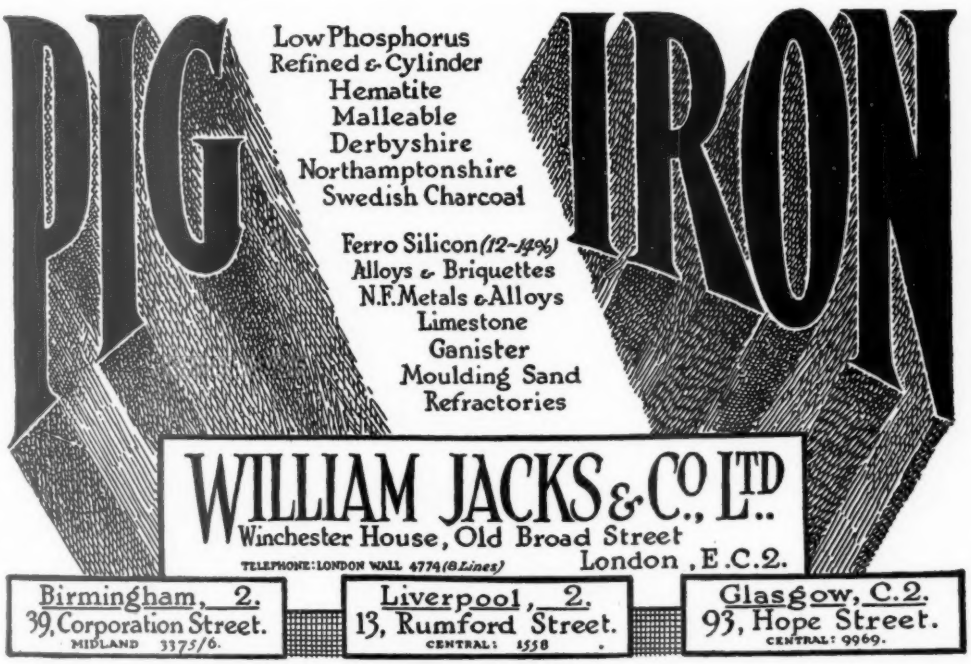
This issue is one celebrating the 75th anniversary of the establishment of the company. It is interesting to note that in 1886, Mr. J. Gray Buchanan, J.P., joined the firm and for the major part of the life of the company has been at the helm. The review follows the same pattern as earlier ones and excludes the foundry industry from its purview. Thus the main interest to founders is the statistical information given on the raw materials the industry uses.

People and Pipe; issued by the American Cast Iron Pipe Company, Birmingham, Alabama, USA.

This handsome brochure has been compiled for the dual purpose of paying homage to the founder of the company, Mr. John Joseph Eagan, and to mark the golden jubilee of its inception. Mr. Eagan must have been a man of outstanding integrity and character. In his will, he left the whole of his holding in the company in a trust designed to be of benefit to the employees. This will could have been contested by his widow, but instead she consented to serve on the board of directors. The brochure tells the story of the small beginnings of the firm, when it used the pit method of casting, through the sand-spun system of manufacturing, to its present position as a world-renowned cast-iron pipe foundry.

Outline of Training for Apprentice Moulders; published by the Council of Ironfoundry Associations, 14, Pall Mall, London, S.W.1.

This report is from a sub-committee of the Recruitment, Training and Education Committee of the CFA, and is designed to serve the widest variety of foundries using the services of skilled moulders. No separate training in coremaking is included, but the apprentice passes through this department. Neither the period of the apprenticeship nor the student days, or hours, is scheduled, it being up to each foundry to establish these. Wisely, certain subjects are made optional, as for instance loam moulding, which is not practised in all foundries. This pamphlet is being widely circulated amongst ironfounders, but no doubt a limited number is available to other sections of the industry which are equally interested in the training of apprentice moulders.



Company News

DERBYSHIRE CARRIAGE & WAGON COMPANY, LIMITED—Arrangements are being made to market the 5s. ordinary shares of the company on the Sheffield Stock Exchange. Issued capital is £200,000 in the 5s. one-class shares.

BRITISH INSULATED CALLENDER'S CABLES, LIMITED—The board has declared an interim dividend of 4 per cent. on £12,350,000 ordinary capital on account of 1955. For 1954 there was a 2½ per cent. interim and a 7½ per cent. final dividend, less tax, also 2½ per cent. from realized capital profits, without deduction of tax.

STERLING INDUSTRIES, LIMITED—Shareholders are informed by their chairman, Mr. R. A. Harding, that the company's present order-book amounts to approximately £1,000,000. Owing to the credit squeeze, however, the company's bankers have requested a 10 per cent. reduction in the present £150,000 overdraft facilities by the end of this year.

WAILES DOVE BITUMASTIC, LIMITED—An effective increase of 2½ per cent. in the total dividend and higher profits are announced for the year ended September 30, 1955. The directors recommend a final dividend of 20 per cent. making a total of 27½ per cent. on the £300,000 ordinary capital as increased by a one-for-two scrip issue. For the previous year distributions totalled 37½ per cent., including a 2½ per cent. bonus on the old capital.

ALLIED IRONFOUNDERS, LIMITED—The board announces a dividend on the 7 per cent. cumulative preference shares at the rate of 3½ per cent. actual, for the half year ended September 30, 1955, and an interim dividend on the ordinary share capital in respect of the year ending March 31, 1956, at the rate of 5 per cent. actual, both less income tax at 8s. 6d. in the £ and payable on January 1, 1956, to registered holders on December 3. Profits for the first half of the year, including the results of Wallis & Company (Long Eaton), Limited, show an increase; those for the second half are expected to fall compared with the corresponding period of last year. The directors do not anticipate a reduction in the year's ordinary dividend.

Hydrogen in Steelmaking

Hydrogen in steelmaking is discussed by John Chapman in *Jernkontorets Annaler*, Vol. 139, No. 9, 1955. He points out that the principal source of hydrogen in steelmaking is water-vapour in the atmosphere and in the combustion gases of the open-hearth. Moist materials added to the slag contribute hydrogen, especially after deoxidation. Moist refractories give up hydrogen to the steel, especially to killed steel. The absorption of hydrogen from moisture increases as the oxygen content of the metal decreases. The following measures are proposed by the author for limiting the hydrogen content of steels: (1) A vigorous "boil" should be maintained in order to flush the hydrogen from the bath and to attain a minimum value. If blocking in the furnace is necessary, the heat should be tapped as soon thereafter as possible. (2) Ladle and runner refractories should be completely dry when "killed" steels are to be tapped. (3) Additions made after the completion of the boil should be completely free from moisture. (4) The use of tar and other hydrogenous mould coating should be avoided where hydrogen is a problem.

Contracts Open

The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained. Details of tenders with the reference ESB can be obtained from the Board of Trade Export Services Branch, Lacon House, Theobalds Road, London, W.C.1 (telephone: CHAncery 4411, ext. 738 or 771), unless otherwise stated.

BELFAST, January 2—Iron castings for the 14 months commencing April 1, 1956, for the City Council. The City Surveyor's Department (Room 81), City Hall, Belfast.

CAMBORNE (CORNWALL), January 28—Galvanized and copper tubes and fittings for the year ending March 31, 1957, for Camborne-Redruth Urban District Council. Mr. S. C. Wilson, clerk to the council.

EGYPT, January 11—12-in. fuel oil pipeline from Mostorod to Helwan, for the Petroleum Pipelines Administration, Cairo. (ESB/26504/55.)

FORMOSA, January 10—Water treatment plant, for the Central Trust of China, Purchasing Department. (ESB/26628/55.)

HEREFORD, January 9—Iron castings for the year ending March 31, 1957, for the City Council. Mr. F. Margerison, city surveyor, Town Hall, Hereford.

ILFORD (ESSEX), January 9—Engineers' sundries, tools, nails, screws, etc., for the 12 months ending March 31, 1957, for the Borough Council. Mr. E. J. Mulder, borough engineer and surveyor, Town Hall, Ilford.

KOREA—Rolling mill plant, for the Han Yung Metal Industrial Company, Inchon. (ESB/26520/55.)

LONDON, E.C.1, January 2—Castings for the 12 months commencing April 1, 1956, for the Metropolitan Borough of Finsbury. The Borough Engineer, Finsbury Town Hall Annexe, Rosebery Avenue, E.C.1.

LONDON, W.5, January 21—Iron castings, lamp columns, and ventilation columns, for the 12 months commencing April 1, 1956, for Ealing Borough Council. The Borough Engineer and Surveyor, Town Hall, Ealing, W.5.

NORTHAMPTON, January 9—Cast-iron gully grates and frames, manhole covers, etc., for the 12 months commencing April 1, 1956, for Northamptonshire County Council. The County Surveyor, County Offices, Guildhall Road, Northampton.

SLEAFORD (LINCOLNSHIRE), January 9—Iron castings for the year ending March 31, 1957, for the County Council. The County Surveyor, County Offices, Sleaford.

SOUTH AFRICA, January 6—Air compressors, for the Stores Department of the South African Railways. (ESB/26698/55.)

SOUTH AFRICA, January 10—Floor grinding machine, for the Stores Department of the South African Railways. (ESB/26423/55.)

SOUTH AFRICA, January 10—Surface grinder, for the Stores Department of the South African Railways. (ESB/26739/55.)

WOLVERHAMPTON, January 3—Cast-iron gully gratings, manhole covers, etc., for the 12 months from April 1, 1956, for the County Borough Council. The Borough Engineer, Town Hall, Wolverhampton.

Foundry Accidents

The table below shows the number of reportable accidents which have occurred in metal founding during the last seven years.

Year.	Fatal.	Non-fatal.
1948	29	12,482
1949	20	11,003
1950	24	10,740
1951	22	11,033
1952	31	11,232
1953	20	9,999
1954	19	9,221

FIVE EMPLOYEES at the Northern Aluminium Company's foundry and forge at Middlemore Road, Handsworth, Birmingham, were recently presented with watches to mark their 25 years' service with the company. The recipients were Miss E. Buswell (telephone operator); Mr. R. H. Fellows (development superintendent); Mr. B. Ashington (coremaker); Mr. W. T. Wright (moulder) and Mr. C. Hampton (fettler). In all cases the presentations were made by Mr. Fraser W. Bruce, the managing director.

New Patents

(Copies of complete specifications are obtainable from the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, London, W.C.2, price 3s.)

741,003. Imperial Chemical Industries, Limited, Imperial Chemicals House, Millbank, London, S.W.1, and P. L. P. Berry, 28, Weymoor Road, Harborne, Birmingham, 17.

Titanium-base alloys suitable for casting, which retain good strengths at elevated temperatures and yet possess sufficient ductility for fabricating operations. They have an alpha or substantially alpha structure, consisting of tin 0.5 to 22, aluminium 0.5 to 12 per cent., the balance, apart from impurities, being titanium.

741,035. Wistna Ofenbau-Gesellschaft mit beschrankter Haftung, Wiesenstrasse 134, Dusseldorf-Heerdt, Germany.

A melting furnace so mounted that it will rock about a central horizontal axis, for the melting of shavings and waste of light metal. Detailed drawings and description are given in the specification.

751,053. Hadfields, Limited, East Hecla Works, Sheffield, 9.

A non-magnetic austenitic alloy-steel which after a precipitation-hardening treatment will have a yield point of at least 40 tons per sq. in. It consists of carbon 0.3 to 9, silicon 0.2 to 2.0, manganese 6.0 to 20.0 per cent., chromium not more than 8.0, nickel not more than 12.0 per cent., and vanadium 1.0 to 4.0 per cent. The remainder is iron and impurities. The total manganese, chromium and nickel content should not exceed 28 per cent. The chromium content should be low enough to ensure that the steel is non-magnetic.

741,158. Allegheny Ludlum Steel Corporation, Brackenbridge, Allegheny, Pennsylvania, USA.

Improved ferrous alloys in particular austenitic chromium/nickel/titanium ferrous alloys suitable for use in aircraft engines for highly-stressed rotating parts, which can be produced on a commercial production basis, simply and inexpensively.

741,173. Wellworthy, Limited, Lymington, Hampshire.

A light-metal piston for diesel and semi-diesel engines of the kind in which a heat-resisting part or member is fitted as an insert into the piston crown for protecting the light metal of the piston from overheating or burning. The piston is made from an aluminium alloy and the insert is bonded into the piston material. The insert is first submitted to a surface-treating process which enables the insert to become bonded with the aluminium alloy when the aluminium alloy is cast around it.

741,215. Aktiebolaget Westin and Backlund, 8 Liljeholmsvagen, Stockholm, 9, Sweden.

A machine for producing shell moulds and patterns from a mixture of sand and a thermosetting agent. The sand is caused to solidify on the pattern in the form of a shell which is hardened or cured by heat. The mould-forming device consists of means whereby two containers adapted to receive the mixture are placed by means of an inverting device, so that application of a preheated pattern or pattern unit to one of the containers is effected in one position. At a second successive position, the formation of a shell mould in the pattern or pattern unit is effected. The inverting device moves the one container and its applied pattern into an inverted position spaced from the initial position and then back again. A second container and pattern is disposed in the initial position during the time the first container and its pattern are in the second (or inverted) position. Means are also provided for the preheating of the patterns or pattern units.

Changes of Name

Among companies which have recently changed their names are those listed below. The new titles are given in parentheses.

Sellman & Hill, Limited, 14, Bath Road, Wolverhampton (Automation Jigs & Tools, Limited).

Sanders Steel Case Company, Limited, Orwell Works, Ipswich, Suffolk (Steel Case Company, Limited).

Quasi-Arc Company, Limited, Bridgewater House, Cleveland Row, London, S.W.1 (Quasi-Arc, Limited).

Wades (Metal Spinners), Limited, Arden Works, Fenton Road, Halifax (Wades (Halifax), Limited).

London Welsh Trust, Limited, agricultural engineers, etc., of 8, Queen Street, Cardiff (Swipes, Limited).

D.T. & G. (Liverpool), Limited, 5, Camden Street, Liverpool (D.T. & G. (Designs, Tools & Gauges), Limited).

Hamstead Alloy Castings, Limited, 109, Colmore Row, Birmingham (Joseph Fray (Alloy Castings), Limited).

Production-Engineering, Limited, 12, Grosvenor Place, London, S.W.1 (P. E. Management Group, Limited).

Ocean Coal & Wilsons, Limited, 52/54, Gracechurch Street, London, E.C.3 (Citygate Investment Company, Limited).

Norwood Steel Equipment (London), Limited, 149, Borough High Street, S.E.1 (Norwood Steel Equipment, Limited).

Carrick & Foster, Limited, ironfounders, brassfounders, etc., of Castlefields, Bingley, Yorks (C. & F. Holdings, Limited).

B. V. Williams & Sons (Engineers), Limited, Vulcan Works, 7, Turton Street, Bolton (Jonas Webster (Engineers), Limited).

Gill Automatic Machine Company, Limited, Denby Dale Road, Thornes, Wakefield (Spencers Equipment Company, Limited).

J. Mills (Elland), Limited, sheet-metal workers, etc., of Phoenix Street, Brighouse, Yorks (Reside & Greenwood, Limited).

Coal & Iron Trades Insurance Company, Limited, Equitable House, South Parade, Nottingham (New Era Insurance Company, Limited).

B. & H. Engineering Company, Limited, 4/6, Hammersmith Grove, London, W.6 (Mechanical Handling & Construction Company, Limited).

Wycliffe Foundry & Engineering Company, Limited, Wycliffe Works, Lutterworth, near Rugby (H.J.B. Subsidiary Holdings, Limited).

Cathanode, Limited, manufacturers of electrical apparatus, etc., of Vineyard Walk, Clerkenwell, London, E.C.1 (Bowyer, Smith & Partners, Limited).

J. V. Murray & Company, Limited, mechanical and general engineers, etc., of 6, Essex Terrace, Intown Row, Walsall (Voucher (Fabrications), Limited).

Engineering & Industrial Oil Processing Research Company, Limited, 38, Grosvenor Gardens, London, S.W.1 (Industrial Research & Supply, Limited).

Dartmouth Pattern Making Company, Limited, Bromford Factory Estate, Blakemore Road, West Bromwich, Staffs (Dartmouth Patternmaking Company, Limited).

Increases in Capital

Wilcox & Company (Birmingham), Limited, dealers in engines, presses, pumps, etc., increased by £45,000, in £1 ordinary shares, beyond the registered capital of £5,000.

A. Fallon & Sons, Limited, casters of aluminium, brass, etc., of Wolverhampton, increased by £28,000, in £1 ordinary shares, beyond the registered capital of £4,000.

J. W. Young & Sons, Limited, precision engineers, etc., of Redditch (Worcs), increased by £50,000, in 1s. ordinary shares, beyond the registered capital of £50,000.

Pickerings, Limited, makers of lifts and hoisting machinery, etc., of Stockton-on-Tees, increased by £30,000, in £10 shares, beyond the registered capital of £20,000.

Plenty & Son, Limited, engineers and ironfounders, of Newbury (Berks), increased by £25,000, in £1 unclassified shares, beyond the registered capital of £50,000.

Heeley & Peart, Limited, malleable iron founders, etc., of Birmingham, increased by £42,000, in £1 ordinary shares, beyond the registered capital of £50,000.

Tom Smith & Clarke, Limited, mechanical, electrical, and consulting engineers, etc., of Swansea, increased by £9,500, in £1 shares, beyond the registered capital of £500.

Dollery & Palmer, Limited, makers of pneumatic picks, colliery plant, etc., of London, S.W.1, increased by £25,000, in 10s. deferred shares, beyond the registered capital of £50,000.

English Abrasives Corporation, Limited, Manchester, increased by £579,800, in 149,900 preference and 429,900 ordinary shares of £1 each, beyond the registered capital of £200.

Barnett & Foster, Limited, manufacturers of bottling machinery, etc., of London, N.1, increased by £150,000, in £1 ordinary shares, beyond the registered capital of £1,000.

Painter Bros., Limited, constructional, electrical, and general engineers, etc., of Hereford, increased by £250,000, in £1 ordinary shares, beyond the registered capital of £150,000.

F. T. Products, Limited, manufacturers of steel spring fasteners, etc., of London, E.C.2, increased by £50,000, in 4s. ordinary shares, beyond the registered capital of £50,000.

Company Meeting

HALE and HALE (TIPTON)

(Producers of Fine Blackheart Malleable Iron)

Considerably Increased Demand for Products

Mr. W. Edgar Hale on Group's Sound Position

The 19th annual general meeting of Hale and Hale (Tipton), Limited, was held on December 14 at Dudley. MR. R. C. LEPPINGTON (vice-chairman & managing director) presided in the unavoidable absence of the chairman, Mr. W. Edgar Hale, M.I.MECH.E. The following is an extract from the chairman's circulated statement:—

The profit and loss account of the holding company shows a trading profit of £69,083, which is an increase of £17,304 as compared with the figure of £51,779 for the previous year. There is a net profit for the year of £28,596, an increase of £8,800 as compared with the figure of £19,796 for the previous year. Your directors recommend a final dividend on the ordinary shares at the same rate of 17½ per cent., less tax, to bring the total distribution for the year up to the rate of 25 per cent., less tax, as has been consistently maintained for several years.

Consolidated Accounts

The consolidated trading profit for the year amounts to £85,087, as compared with £76,886 for the previous year, and thus records an increase of £8,201; to the figure of consolidated trading profit are added investment income, etc., of £2,431 and a credit for taxation of £2,090 to give a total of £89,608 on the credit side. Directors' fees, auditors' fees, and depreciation and obsolescence, totalling £15,248, and taxation at £36,932 are deducted to leave a consolidated net profit of £37,428. The corresponding profit for the previous year amounted to £32,429, so that there has been an improvement of £4,999.

The group has working capital as represented by the excess of current assets over current liabilities of £193,436, which compares with the previous year of £234,839.

Production and Sales

As you will observe from the accounts, our company, of which we are all so justifiably proud, has recovered from the slight setback which occurred during the year of 1954, when output for part of that year was seriously disturbed by many of the engineering firms throughout the country deciding to reduce their stocks, the result of which was materially to lessen the total of our sales for that year. However, that is all behind us now, and over the past 12 months there has been a considerable increase in the demand for our products which, due to the shortage of labour, has necessitated our extending our delivery period. In spite of labour shortages we have been able to increase our output of castings over the previous year by some hundreds of tons. This improvement has been achieved by the increased mechanization mentioned in last year's report.

Since my last report there has been an improvement in selling prices, but a great deal of the advantage has been offset by increases in the cost of raw materials, fuel, transport, and labour. The undesirability of increasing prices is generally appreciated, but there is very little margin left to the producer for absorption of any further increases he may have to meet. By force of circumstances he will be compelled to pass any such increases on to the consumer. We can only hope that greater consideration will be given before further advances are called for in raw materials, fuel, and transport, for there must be an end to it if we are to continue at the present full production level. You may depend on it that, whatever the outcome, we shall continue to offer products of the highest quality only, at the most economic prices, and to give our customers good value and service.

I would say that we are so well entrenched and extremely well regarded by consumers and suppliers that the future, subject to any extraordinary happenings taking place, is well assured for many years ahead, while on a much broader basis, I would apply the same optimistic note to our national and Commonwealth affairs, for as long as sterling remains cheap in the money markets of the world, then we have a bargaining factor of great power.

Subsidiaries

J. & J. WHITEHOUSE (TIPTON), LIMITED—The Whitehouse Subsidiary is catering in a competitive market abroad, and at the same time supplying a commodity which calls for quite a deal of skill. The number of employees with this knowledge is not high, and, in fact, gets less, but your directors are giving attention to alternative employment in this particular subsidiary.

CHATWINS, LIMITED—This Subsidiary continues to supply a considerable variety of cooking and heating equipment which is well to the fore in design in every way. The Free Standing Cooker represents the most advanced ideas of solid-fuel consumption for the purpose of supplying domestic hot water and cooking, and the one which they sell under the trade name of "Sunbeam Superior" is extremely popular on the market. It is very efficient and convenient, and there is every reason to assume that it is going to be a big seller in the future.

HALE ENAMELLERS, LIMITED—There would appear no question of doubt that they are doing some of the best vitreous enamelling in the country at the present time, and its prospects should be very bright in the future. Much of its output is absorbed by Chatwins, Limited, who hitherto employed outside contractors to do this work.

Current Affairs

The greatest obstruction which industry has to contend with so much is political interference. I have always insisted that politics and commercial life are very unsatisfactory "bed-fellows," and the farther they are kept apart from one another the better it is for all. We have to recognize to-day that a living can be earned in the political arena based mainly on the destruction, which continual disturbances create as between management and employees, by a very small section of the community which perpetrates this evil activity upon the whole nation. As I have said on many occasions, this sort of thing will be dying out soon, as a result of the man-in-the-street enjoying much better standards of education; and while he may not be very vociferous, he is beginning to know what is best for him and his dependants, and when the time comes for him to take action through the ballot box at the time of both national and local elections he will take that action which he knows is best irrespective of other opinions which may be foisted on him by the few with selfish interest and ulterior motives.

The report was adopted.